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Chapter 4
Earth

4.1 Introduction

This chapter addresses the affected environment, impacts to the environment, mitigation measures, and significant unavoidable adverse impacts related to earth for the Brightwater Regional Wastewater Treatment System (Brightwater System). All references and figures cited within this chapter can be found at the end of the chapter.

The content of this chapter differs from the content found in Chapter 4 of the Draft EIS in several ways:

- Groundwater discussions have been moved to Chapter 6, to allow for a greater focus in this chapter on earth-related issues
- The chapter is now organized by system (Route 9–195th Street System, Route 9–228th Street System, and Unocal System). For each system, the discussion is organized by system element (treatment plant, conveyance corridor, and outfall)
- Content has been changed to address comments on the Draft EIS and to provide new and revised project design information

4.1.1 Summary of Comments Received

Comments on the Draft EIS were received from federal, state, and local agencies, public interest groups, and individuals. The majority of the comments fell into the following categories:

- Provide additional information on the seismic considerations within the Brightwater System, and specifically the South Whidbey Island Fault Zone (SWIFZ)
- Discuss in greater detail the geologic hazards at the portal sites.
- Describe the specific Best Management Practices (BMPs) that will be used to mitigate potential earth-related impacts
- Provide additional information on how structures can be designed to mitigate potential damage from liquefaction of soil should it occur during an earthquake

4.1.2 Supplemental Technical Studies and Analyses

The public responded to Chapter 4, Earth, of the Draft EIS with more than 700 comments, ranging in length from one-sentence questions written by individuals to 40-page letters drafted by consultants on behalf of interested parties. The majority of these comments requested additional information on or discussion of the following:

- Erosion control methods and Best Management Practices (BMPs)
- Basic geologic and geotechnical exploration data
- Landslide and slope stability hazards associated specifically with conveyance system portals and with the Route 9–195th Street conveyance system
- Liquefaction potential and its impacts on treatment plant structures and conveyance tunnels
- Handling and disposal of contaminated and non-contaminated soils excavated during construction of the treatment plant and conveyance system
- Impacts to marine sediments at proposed outfall locations
- Mitigation measures for reducing the potential for chemical and wastewater spills during treatment plant and conveyance system operation

The chapter has been updated to include information from technical studies that were conducted after publication of the Draft EIS. These studies are included in Appendices 4-A through 4-D and Appendix 6-B of this Final EIS:

- **Appendix 4-A, Geotechnical Data Report for Proposed Route 9 Treatment Plant Site,** contains boring logs, laboratory test results, observation well readings, and preliminary geologic interpretation from five geotechnical borings drilled in early 2003 at the Route 9 site.
- **Appendix 4-B, Geotechnical Progress Report: Conveyance,** includes geologic, geotechnical engineering, and groundwater elevation data developed during explorations conducted between January and June 2003. These explorations focused on the Route 9–195th Street corridor, which had not been as extensively investigated for the Draft EIS. This appendix includes summary logs for 58 borings drilled during this period.
- **Appendix 4-C, Outfall Geophysical Surveys,** includes the results of over-water geophysical explorations conducted at outfall Zone 7S. The explorations included a bathymetric survey, side-scan sonar imaging, sub-bottom profiling, and seismic profiling.
- **Appendix 4-D, Phase I Environmental Site Assessment—Route 9 Parcels** includes the results of historical records searches, Washington State Department of Ecology file searches, and interviews with property owners and tenants to

determine past and present uses of the parcels on the Route 9 site and the potential for soil and groundwater contamination associated with those uses.

- **Appendix 6-B, Geology and Groundwater,** was prepared to provide a regional synthesis of geologic and groundwater conditions as a basis for impact evaluation. This appendix describes the geologic nomenclature used for the Brightwater project and provides additional information concerning the distribution of geologic units and groundwater in the project area.

4.2 Affected Environment

This chapter describes the existing geologic conditions (topography and stratigraphy; and erosion, landslide, and seismic hazards) that may affect or be affected by the Brightwater System, including the treatment plant, conveyance system, and outfall. The known presence or potential for encountering contaminated soils during construction is also considered. Groundwater, which was discussed in Chapter 4 of the Draft EIS, is now discussed in Chapter 6.

The data used in this evaluation were obtained from published reports on the earth environment, existing field explorations and laboratory testing, and supplemental field explorations conducted by King County as part of this Final EIS, for the Route 9 and Unocal sites and conveyance system alternatives.

4.2.1 Affected Environment Common to All Systems

Regional aspects of the earth environment that are common among the various components of the Brightwater System are presented first. Subsequent sections of this chapter provide discussions of the earth environment as it applies to the individual system alternatives, the Route 9 System alternatives and the Unocal System alternative.

4.2.1.1 Regional Earth Conditions

This section briefly presents the interpretations of regional geologic conditions that apply to all components of all three alternatives for the Brightwater System. Detailed descriptions of the geology and geologic history of the region are provided in Appendix 6-B, Geology and Groundwater.

Interpretations are based on extensive exploration work completed during the past 50 years, including detailed mapping of surface deposits in the project area by Newcomb (1952), Liesch et al. (1963), Smith (1976), and Minard (1985); a U.S. Geological Survey (USGS) groundwater study for Snohomish County (Thomas et al., 1997); current geologic mapping of the project area by the Seattle Area Geologic Mapping Project (SGMP, 2003); geologic data from exploratory borings completed for the Brightwater

System (HWA GeoSciences and Shannon & Wilson, 2002; CH2M HILL/Shannon & Wilson, 2002; CDM, 2003; CH2M HILL/Shannon & Wilson, 2003); and data from numerous water wells in the project area. More subsurface information will be collected throughout 2003 and 2004 as pre-design and design explorations and geotechnical engineering studies continue for the Brightwater System.

Physical Setting

The proposed Brightwater System project area extends approximately 14 miles along the King-Snohomish County line from Woodinville in the east to Puget Sound in the west. The project area is in the central part of the Puget Lowland, which is bounded on the east by the Cascade Range and on the west by the Olympic Mountains. The Puget Lowland is characterized by north-south trending valleys and hills in low relief, with intervening elongated saltwater and freshwater bodies.

The western end of the area is a gently sculpted upland that ranges from 300 to 500 feet above mean sea level (MSL), with west-facing slopes that descend to Puget Sound. This area has been termed the Intercity Plateau (Thomas et al., 1997). Small creeks drain westward off the upland into Puget Sound. In the middle and eastern parts of the project area, the uplands reach 400 to 500 feet above MSL and are heavily dissected by south-flowing streams that drain directly or indirectly into Lake Washington.

Regional Geology

The Puget Lowland is underlain at depth by Tertiary-Period volcanic and sedimentary bedrock and is filled to the present-day land surface with glacial and nonglacial sediments deposited during the Quaternary Period (within the last 2 million years) (Yount et al., 1993). Depth to bedrock beneath the project area is estimated to range from 600 feet to more than 1,000 feet (Jones, 1996).

The Quaternary geologic history of the Puget Sound region is dominated by at least six periods of continental glaciation, when much of low-lying northern North America was covered by continental ice sheets more than 1 mile thick in some places. In the project area, the ice was more than 3,000 feet thick. The most recent continental glacier in the Puget Lowland reached its maximum extent just south of Olympia.

During glacial advances, meltwater and ice scoured the underlying soil and rock, reworking and entraining sediment and carrying it south. As the glaciers retreated, they deposited their sediment load over the uncovered landscape. Between glaciations, erosional and depositional processes worked much as they do today. These processes include sedimentation by overbank flooding in alluvial river valleys, development of alluvial fans or deltas where freshwater streams discharge into water bodies, and deposition of fine-grained lacustrine or marine deposits in freshwater lakes and marine waters.

The most recent glacial deposits are associated with the Vashon Stade of the Fraser glaciation, which occurred locally between 12,000 and 16,000 years ago. Because of erosion between cycles and areas of nondeposition, Vashon-age sediments can lie directly on any of the older pre-Fraser glacial or nonglacial sediments, or they can be entirely absent.

Appendix 6-B, Geology and Groundwater, contains a stratigraphic column that identifies the geologic units in the Brightwater project area as well as three regional geologic cross sections. Figure 4-1 shows surficial geologic conditions in the project area, as developed by the SGMP (2003).

Geologic unit designations follow the nomenclature adopted by the SGMP and are similar to the nomenclature approach used for previous Brightwater reports. The geologic units that occur in the project area are described below.

Deposits from Human Activities

Fill (af)—Fills of various thickness and composition, resulting from land development, are present throughout the project area.

Recent (Holocene) Deposits

Holocene sediments have been deposited in the central Puget Lowland since the disappearance of glacial ice. The sediments were deposited by nonglacial geologic processes that are largely active today, such as erosion, landsliding, and stream action. Because these sediments have not been glacially overridden, they are softer and looser than the underlying deposits.

Peat or Wetland and Marsh Deposits (Qp/Qw)—These deposits are organic-rich alluvial deposits present in poorly drained and intermittently wet areas. Where these sediments are thicker, they are commonly mapped as peat.

Beach Deposits (Qb)—Beach deposits consist of loose sands and gravels deposited by wave action.

Alluvial Fan Deposits (Qf)—These sediments consist of boulders, cobbles, gravel, and sand deposited in lobate forms where streams emerge from confining valleys or ravines.

Mass Wastage Deposits (Qmw)—Mass wastage deposits comprise colluvium, topsoil, and landslide debris that have an indistinct shape but are sufficiently thick and continuous to obscure underlying material.

Recent Alluvium (Qal)—Recent alluvium consists of young stream and river (fluvial) sands and gravels and silty sands, and silts, clays, and silty fine sand deposits commonly containing some wood and organic matter. Recent alluvium fills valley bottoms, including portions of Little Bear Creek, North Creek, Swamp Creek, McAleer Creek, Lyon Creek, and the Sammamish River. In broad stream valleys, such as North Creek, alluvium can exceed 80 feet in thickness. In some areas, the recent alluvium can be subdivided into Younger Alluvium (Qyal) and Older Alluvium (Qoal).

Vashon Glacial Deposits

Vashon glacial deposits were emplaced during the Vashon Stade of the Fraser glaciation, and comprise a well-recognized and widely distributed sequence in the central portion of Puget Lowland.

Recessional Outwash (Qvr)—Recessional outwash deposits consist of coarse-grained fluvial (Qvrf) and fine-grained lacustrine (Qvrl) sediments. Recessional outwash was never overridden and compressed by glacial ice and so is less dense and softer than older deposits. Recessional outwash typically occurs as isolated deposits on upland areas and as more continuous deposits along the walls and bottoms of most major drainages in the project area.

Ice-contact Deposits (Qvi)—These deposits are similar in texture to Qvr, but locally contain a much higher percentage of silt intermixed with lenses and pods of sand, gravel and till and commonly have steeply dipping beds.

Till (Qvt)—Till is the name given to a wide range of sediment types deposited and overridden by glacial ice. The vast majority of the till found along the corridors is lodgment till and is dense to very dense as a result of being overridden by over 3,000 feet of ice. Till has not been reworked by flowing water and consists of a poorly to non-sorted, matrix-supported, structureless deposit (diamict) of widely varying grain sizes, ranging from boulders to clay.

Glacial Diamicton (Qvd)—This is the name given to deposits of somewhat indistinct origin, but which have a grain size distribution similar to till.

Advance Outwash (Qva)—Glaciofluvial deposits of the Vashon Stade, also called Vashon Advance Outwash and known locally as the Esperance Sand, occur widely across the project area. The deposits are typically a homogeneous, clean, fine-to-medium sand, although some portions are composed of gravelly sand.

Lawton Clay (Qvlc)—When glaciers entered the Puget Lowland, they dammed the north end of Puget Sound, creating a large freshwater lake in which fine, glacially derived sediments could settle out. These glaciolacustrine deposits (which may correlate with the Transition Beds of Minard [1985]) typically consist of interbedded clayey silt, silty clay, and silt and fine sand mixtures.

Pre-Fraser Deposits

Older glacial and nonglacial deposits are present below Vashon glacial deposits in the project area. For purposes of this EIS, these older deposits are divided into those of potential glacial and nonglacial origin. The Olympia Beds and Whidbey Formation are also described because these are discrete geologic units recognized in the project area.

Glacial Pre-Fraser Deposits

Glaciofluvial (Qpogf)—These coarse-grained units were deposited by glacial outwash rivers and streams in geologic environments similar to the Vashon recessional outwash or Vashon advance outwash, resulting in similar composition and texture.

Till (Qpogt) and Diamicton (Qpogd)—These deposits are similar to Vashon till and diamicton, respectively.

Glaciolacustrine (Qpogl)—These deposits have a similar depositional environment, texture, and composition to Vashon glaciolacustrine (Lawton Clay) deposits.

Glaciomarine (Qpogm)—These deposits are largely similar to till in terms of texture and composition, but often with greater clay or clayey matrix and more frequent sand and gravel dropstones rained out of floating ice. Glaciomarine sediments may contain some shells and shell fragments, and are likely to contain interbeds or large inclusions of granular material.

Nonglacial Pre-Fraser Deposits

Nonglacial fluvial (Qpfnf)—These are river and stream deposits composed of silty sand, sand, and sand and gravel mixtures, commonly with trace-to-abundant organics.

Nonglacial lacustrine (Qpfnl)—Nonglacial lacustrine sediments are lake deposits consisting of silts, clays, and fine sands. They may contain trace-to-abundant organics and peat. Interbedded coarse-grained sand and gravel lenses are commonly present within nonglacial lacustrine deposits.

Peat (Qpfpt)—Pre-Fraser peat deposits are similar to younger peat deposits, although typically much harder.

Olympia Beds (Qob)—The Olympia beds are nonglacial deposits of thinly bedded sand, silt (locally organic-rich), peat, and volcanic ash.

Whidbey Formation (Qwb) –The Whidbey Formation is a group of older nonglacial sediments deposited in the central Puget Lowlandprior to the Olympia interglacial period.

Seismicity

The Puget Lowland has experienced earthquakes in the past and is expected to experience them in the future. This section summarizes the sources of these seismic events and the potential ground motions resulting from them.

The Puget Lowland is located at the leading edge of a subduction zone—an elongated region where two tectonic plates collide, resulting in one plate overriding the other. While not fully understood, the area's tectonics and seismicity are dominated by the convergence and subduction of the western oceanic Juan de Fuca Plate beneath the eastern continental North American Plate. The estimated convergence rate is 1.2 to 1.6 inches per year (Riddihough, 1984), with the Juan de Fuca Plate moving beneath the North American Plate in a northeasterly direction relative to the continent.

Seismic events in the Puget Sound region are generally believed to result from three source mechanisms:

- The large Cascadia source off the coast of Washington
- The intraplate source occurring 18.5 to 43.5 miles beneath Puget Sound
- Random crustal events that could occur in the upper 20 miles anywhere in the region

The 1949 Olympia earthquake, the 1965 Sea-Tac earthquake, and the 2001 Nisqually earthquake are recent events associated with the intraplate source mechanism.

The known fault that is nearest the project area is the South Whidbey Island Fault Zone (SWIFZ). This is a northwest-trending zone, estimated to be 4 to 7 miles wide, that includes several splays of steeply dipping faults. Geophysical data indicate that the fault zone extends southeast across Puget Sound (Jones, 1996). The extension of the fault onto the mainland has been postulated, as shown in Figure 4-2. A recent, as yet unpublished, refinement of data by the USGS defined three northwest-trending linear aeromagnetic anomalies, or lineaments, that may represent features associated with the fault zone (Troost, 2003). This work suggests that the fault zone could extend more to the south than previously thought. The southernmost anomaly passes approximately 1.5 miles north of the Unocal site, while the northernmost anomaly passes approximately 0.5 mile north of the Route 9 site. The locations of the anomalies, however, are not well defined because they represent geologic features that may or may not be associated with active faulting and are the subject of ongoing USGS studies. The Brightwater design teams are working with the USGS SWIFZ researchers to incorporate the latest information into the facility design.

Regional Geologic Hazards

As discussed below in the Regulatory Environment section, local critical area regulations require the identification and mapping of erosion, landslide, and seismic (liquefaction) hazards. In addition, settlement of soft soils due to liquefaction is also considered a geologic hazard. While not a "geologic" hazard, soil contamination is also discussed in this section. Figure 4-3 shows a map of these hazards in the project area based on local agencies' critical area inventories. Each of these geologic hazards can be expected to occur to some degree throughout the project area, and each is briefly described below. Construction-related hazards, including the potential to encounter boulders, nested gravelly cobble units, and/or bedrock are discussed in Appendix 6-B, Geology and Groundwater.

Erosion Hazards

An erosion hazard is present where soils may experience severe to very severe erosion from construction activity. Depending on soil type, erosion may cause localized sloughing of hill slopes and subgrades during wet weather. Removal of vegetation, modification of topography, and uncontrolled surface runoff can accelerate erosion in erosion-prone soils.

Erosion-prone soils include those with a high percentage of silt or clay, or those that overlie a less permeable soil layer. The hazard potential increases when such a soil occurs on a moderate-to-steep slope. A slope of 15 to 40 percent is classified as a potential erosion hazard by King and Snohomish Counties if the soil is erosion prone; a slope of more than 40 percent is classified as a hazard regardless of the soil type.

Landslide Hazard

Areas subject to landslides are determined by a combination of geologic, topographic, and hydrologic factors. Landslides also can be induced by seismic events. Landslide hazard areas are mapped if there is evidence of past landsliding; if the slope is 15 to 40 percent and the soils are underlain by silt or clay that can perch groundwater; or if the slope is steeper than 40 percent, regardless of soil type.

Seismic Hazards

Seismic hazard is generally defined as a severe risk of earthquake damage from seismically induced ground rupture, slope instability, or soil liquefaction. Detailed exploration and analysis are required to determine susceptibility to earthquake damage.

Areas of potential ground rupture are shown in Figure 4-2 and discussed under Regional Seismicity. Ground rupture is the general term used to characterize an area where fault movement results in a distinct offset at the ground surface, or possibly a crack or fissure. Because seismic hazards associated with ground rupture have historically been difficult to assess in the Puget lowlands, regulatory agencies have not included fault rupture in their hazard maps (Figure 4-3).

Seismic hazards associated with slope instability are typically in areas that already meet the landslide hazard, as defined above. Therefore, the hazard maps (Figure 4-3) identify only potential liquefaction hazards as seismic hazards.

Soil liquefaction and accompanying settlement, lateral spreading, or flotation of lightly loaded buried pipes or structures can occur where the groundwater is near the surface and the soils have low cohesion (e.g., fine-grained sand, silt, or sandy silt) and low density. Therefore, potential seismic liquefaction hazards are indicated in postglacial sedimentary deposits with relatively level terrain near water bodies and in locations of known past earthquake damage.

Settlement Hazards

Areas underlain by loose compressible sediments, particularly thick peat deposits, can be subject to ground settlement during, and sometimes after, construction. In most cases, areas mapped as seismic hazards associated with liquefaction coincide with areas of settlement hazard. These areas occur primarily in the stream valleys crossing the Brightwater project area and in low-lying areas adjacent to Lake Washington.

Soil Contamination Hazards

Soil contamination hazards at the treatment plant sites are discussed separately in the treatment plant sections. Geotechnical explorations were conducted in late 2001 and early 2002 to identify potentially contaminated sites in the conveyance corridors and portal siting areas. Twenty-seven geotechnical borings were completed along the Unocal corridor, the effluent portion of the Route 9–195th Street corridor and the Route 9–228th Street corridor, and portions of the Route 9 influent corridor. In addition, 28 geotechnical borings were completed in 2003 along the Route 9–195th Street corridor. The top 50 feet of soil in each boring was field screened for volatile contaminants such as gasoline, diesel, and oil. Field screening during the preliminary exploration program identified no contaminated soils or sediments. However, given the spacing of the preliminary borings, contaminated soil or sediments may be present in untested areas. This is particularly possible in those areas with a history of commercial or industrial activity.

In addition to geotechnical borings, a search was made of federal and state databases that inventory land parcels known to have current or past contamination or that produce, handle, or store hazardous materials. No known substantially contaminated sites, such as Superfund sites, are listed on the federal databases along any of the corridors. Eight sites on the State of Washington's Confirmed and Suspected Contaminated Sites List are located near the Unocal corridor and associated portal siting areas. Six of these sites have reportedly been cleaned up, and two sites (Unocal Edmonds Bulk Fuel Terminal [Unocal site] and Kenmore Industrial Park) are, or will be, undergoing remedial action with oversight from the Washington State Department of Ecology (Ecology). Nine sites on the list are located near the Route 9 corridors and portal siting areas. Three sites have been ranked by Ecology and are awaiting remedial action; and one site is awaiting an assessment of site contamination.

Bathymetry of the Puget Sound Shoreline in the Project Area

The stability and bathymetry (contours of the seafloor) of the shoreline region are important for selecting the site where an outfall pipeline makes the transition from onshore to offshore. Geophysical properties of the outfall zones can significantly affect the feasibility, construction cost, and longevity of the outfall. A large submarine canyon, for example, may be impassable for all practical purposes; or, if the area is susceptible to submarine slides or slumps, these could bury the diffuser and thus shorten the lifetime of outfall operations. Three geophysical investigations were conducted for the Brightwater project to identify zones where the bottom slopes and other geological conditions are suitable for marine outfall construction and operation.

The first study (King County, 2001) was a survey that mapped the bathymetry along the shoreline of north King and south Snohomish Counties. As a result of this survey, Zones 6 and 7S were identified as prime candidate outfall locations. Because the Nisqually earthquake occurred not long after the survey, the second survey (King County, 2002a) was made after the earthquake to determine if anything had changed. This subsequent survey found no evidence of earthquake-induced slope failures in Zones 6 and 7S.

The second study mapped the bathymetry more closely and characterized the sediments below the seabed surface in the alternative outfall zones to identify materials that could affect construction techniques (for example, a large boulder field could prevent tunneling).

The third study was conducted to further refine information in the Final EIS and to support predesign activities (Appendix 4-C, Outfall Geophysical Surveys).

Based on the geophysical investigations and evidence collected after the Nisqually earthquake, neither outfall zone is anticipated to contain geological hazards that would prohibit outfall construction and operation. Results from the geophysical investigations are summarized in this chapter for each outfall zone. The bathymetry of each outfall zone is shown in Figures 3-9 and 3-21 of Chapter 3 for the Zone 7S and Zone 6 outfall zones, respectively.

Sediment Quality in the Outfall Zones

Sediment quality in the two outfall zones was evaluated to establish baseline conditions prior to operation of the outfall and to identify any contamination issues that would need to be addressed prior to and during construction (King County, 2002a). Surface sediment samples were collected for chemical analysis from three randomly selected locations in outfall Zones 6 and 7S. The analysis included all trace metals and organic compounds regulated under the Washington State Sediment Management Standards and the Puget Sound Dredged Disposal Analysis program, and those included on the U.S. Environmental Protection Agency (EPA) priority pollutant list. Nearshore surface sediment samples were also collected from three locations along the 20-foot bathymetric contour lines in both outfall zones and analyzed for the same suite of analytes. Sediment was collected from the uppermost 10 centimeters (3.9 inches), the area in which biological activity occurs. The sampling and analysis followed guidance recommended under the Puget Sound Estuary Program.

Sediment quality was similar for the two outfall zones. Small variations in physical properties, such as grain size distribution and organic carbon content, appeared to be associated with the depth of the sampling location. Sediment concentrations of trace metals and organic compounds met all applicable sediment standards and criteria at every sampling location. Slightly elevated concentrations of some trace metals and organic compounds were detected at two nearshore sampling locations north of Zone 7S (relative to other nearshore stations) and may be associated with a stormwater outfall located on the north side of Point Wells.

4.2.1.2 Regulatory Environment

The regulatory environment for earth includes local regulations relating to geologic hazards, and federal and state regulations pertaining to seismic design and soil contamination.

Federal Regulations

Certain earth-related features of the Brightwater Treatment Plant are regulated at the federal level, including geologic (seismic) hazards and chemical contamination.

Seismic Design Standards

Brightwater structures will be designed in accordance with the 2003 International Building Code (IBC), which will become effective in Washington State in 2004. The code provides a method to determine the ground acceleration for an earthquake that has a 2 percent chance of occurrence over a 50-year design life (roughly a 2,500-year recurrence interval) for municipal works such as water treatment plants. The method considers the soil types at the site and the importance and function of the structures. The code also dictates specific design checks related to these accelerations. In addition, the design ground accelerations and associated response spectrum will be modified, if appropriate, based on ongoing research by regional seismologists with regard to the South Whidbey Island Fault.

Federal regulations and the IBC do not cover slope stability calculations. However, the seismic accelerations developed from the IBC, or modified versions of these accelerations, will be used in slope stability calculations. Local practice is to use a global safety factor of 1.0 to 1.1 for global slope stability, with a seismic coefficient of one-half to two-thirds of the peak ground acceleration predicted for a site. The IBC dictates safety factors that consider seismic loading for the local or internal stability of walls.

The IBC does not provide a standard method for designing structures that would be built in liquefiable soils. Instead, it is left to the geotechnical engineer to design structures with consideration of post-liquefied soil strength and the potential for settlement or lateral movement. Design criteria with respect to liquefaction at the two alternative treatment plant sites have not been completely developed at this time, but all major structures and pipelines would be protected from liquefaction. For example, structures on the lower yard at the Unocal site would be pile supported, and pipes would have flexible couplings at connections to structures. Similar measures will be necessary for conveyance pipelines crossing through areas of liquefiable soils.

Contaminated Soil and Groundwater

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, 42 USC 9601), also known as "Superfund," regulates uncontrolled hazardous materials and contamination. CERCLA establishes a process for investigating, documenting, and cleaning up contaminated sites. In addition, CERCLA provides a legal mechanism to assign liability for the costs of investigation and cleanup. No CERCLA-regulated sites are currently identified at either of the treatment plant sites, along the conveyance corridors, or in the outfall zones.

Washington State Regulations

Earth-related activities also must comply with state regulations addressing geologic hazards, erosion control, and chemical contamination.

Geologic Hazards

Washington State's Growth Management Act (GMA), Chapter 36.70A RCW, requires all cities and counties to identify critical areas within their jurisdictions and to formulate development regulations for protecting those areas. Among the critical areas defined by the GMA are Geologically Hazardous Areas that because of their susceptibility to erosion, sliding, earthquake (including liquefaction), or other geologic events, are not suited for development consistent with public health and safety concerns.

Erosion Control

Where more than 1 acre is disturbed by clearing, grading, excavation, and other construction activities, erosion must be controlled under National Pollutant Discharge

Elimination System (NPDES) regulations for stormwater discharges. EPA has delegated regulatory authority for this national program to the Washington State Department of Ecology (Ecology); therefore, Ecology would issue an individual NPDES permit to regulate construction of Brightwater facilities. NPDES regulations require preparation and implementation of a plan to prevent stormwater pollution, including erosion control measures. NPDES regulations also address discharge of offsite stormwater, discharge of groundwater removed to facilitate construction, and requirements for inspection and reporting.

Contaminated Soil

The Model Toxics Control Act (MTCA, Chapter 70.105D RCW) and the associated rules (WAC Chapter 173-340) establish administrative processes and standards for identifying, investigating, and cleaning up sites in Washington State where releases of hazardous substances to soil (and other media) pose a threat to human health or the environment. MTCA is administered by Ecology.

Underground storage tanks (USTs) and leaking USTs are regulated by Ecology under Chapter 173-360 WAC. Soil contamination associated with leaking USTs is typically cleaned up under the UST regulations, but in accordance with the primary MTCA authority for dealing with releases of hazardous substances.

Contaminated Sediment

Ecology also administers the Washington State Sediment Management Standards (Chapter 173-204 WAC), which govern the cleanup and disposal of contaminated sediments in the aquatic environment. The Washington State Department of Natural Resources (DNR) is involved in characterization and cleanup of contaminated soil and sediments on state-managed aquatic lands. Disposal of excavated sediments, whether contaminated or uncontaminated, is regulated by the Puget Sound Dredged Disposal Analysis program and administered jointly by Ecology, DNR, and the COE.

Local Regulations

The GMA requires special studies and design for development within hazard areas to protect the environment and public health and safety. Cities and counties in the project area have classified and mapped geologic hazards for their respective communities as part of developing critical areas regulations for building and development, as well as to comply with GMA requirements. The critical area maps identify potential landslide, erosion, and seismic hazards.

4.2.2 Affected Environment: Route 9 System

4.2.2.1 Treatment Plant: Route 9

Existing conditions at the Route 9 treatment plant site are described below. The description is based on published geologic information described previously under Regional Earth Conditions, as modified by specific onsite geotechnical investigations conducted for this EIS.

Topography

Generally, the Route 9 site slopes gently to the west at an average slope of about 8 percent. Most of the site's eastern boundary is a moderate-to-steep west-facing slope ranging from 10 to 30 percent in grade. Elevations range from approximately 150 feet 1988 National Geodetic Vertical Datum (NGVD) at the southwest corner to 230 feet NGVD at the northeast end of the proposed treatment facilities at the Urban Growth Area boundary, as shown on Figure 4-4.

Geology and Soil Types

King County conducted two subsurface exploration programs, including soil borings and geotechnical laboratory tests, at the Route 9 site to gather site-specific geology information. The geologic units used in the discussion below are described in detail in Appendix 4-A, Geotechnical Data Report: for Proposed Route 9 Treatment Plant Site, and Appendix 6-B, Geology and Groundwater. Descriptions of geology and soil types below a depth of about 100 feet are based on the results of a single boring, PB-12, drilled in the southwestern portion of the site.

In general, the near-surface materials across the majority of the Route 9 site are either Vashon Recessional Outwash or fill. The Vashon Recessional Outwash is high-permeability, loose-to-medium-dense, silty sand to silty sand with gravel (Qvr). The fill is reworked Qvr that also includes some crushed surfacing, topsoil, rock fragments, and debris. These two units together range in thickness from 10 to 30 feet, with the greater thickness at the southern end of the site.

Elsewhere in the region, Vashon Advance Outwash (Qva) stratigraphically underlies Vashon till and diamicton (Qvt and Qvd), but the Vashon Advance Outwash appears to have been completely eroded or reworked at the Route 9 site. Similarly, Lawton Clay glaciolacustrine deposits (Qvlc) appears to have been eroded over most of the Route 9 site and are present only at the ground surface on the upper slopes.

The Vashon units at the Route 9 site are underlain by low- and moderate-to-high-permeability pre-Fraser glacial deposits. Of these, the glaciofluvial outwash deposits (Qpgf) have been carbon dated at more than 50,000 years old, making them pre-Olympic stratigraphically. The diamicton deposits overlying the Qpgf have a relatively low permeability, which confines the groundwater within the outwash deposit and results in a groundwater pressure head 15 feet higher than hydrostatic at some locations. The outwash deposits lie about 90 to 140 feet below ground surface (bgs) and are underlain by less permeable till and diamicton deposits that extend to about 190 feet bgs.

Nonglacial lacustrine (Qpnl) deposits extend from about 190 to 440 feet bgs. These deposits consist primarily of silt and fine sandy silt with occasional interbeds of clay and silty fine sand. The material generally has a low vertical permeability and a low to moderate horizontal permeability.

Below a depth of 440 feet bgs, the Route 9 site is underlain by glaciomarine deposits (Qpgm) to the maximum depth explored (500 feet bgs). This material is an unsorted mixture of clay, silt, sand, and gravel and commonly grades into and contains layers of lacustrine material (Qpgl) that usually has a low permeability. Even where it has a high permeability, the permeable soil is not laterally extensive and therefore is not readily recharged by groundwater.

Geologic Hazards

The potential geologic hazard areas at the Route 9 site are shown in Figure 4-5. Geologic hazards include erosion, landslide, and seismic hazards. As noted above, additional construction-related hazards are discussed in Appendix 6-B, Geology and Groundwater.

Erosion Hazards

Erosion hazards are restricted primarily to the slope along the eastern boundary of the site east of the railroad tracks, and range from 10 to 30 percent in grade. Erosion hazard is higher in areas of exposed soil where vegetation is not well established and stormwater runoff is poorly controlled. However, the eastern slope of the Route 9 site is currently well vegetated and not believed to be eroding.

Landslide Hazard

Under the regulatory slope criteria, a moderate landslide hazard exists at the far eastern boundary of the site east of the railroad tracks. A portion of the slope east of the existing Stockpot Culinary Campus building moved in late 1998 after site grading to construct the Stockpot building removed the toe of the slope (Lovell-Sauerland, 1999). The slide was stabilized with a cylinder pile wall.

Seismic Hazards

Structures at the Route 9 site will be designed in accordance with the International Building Code (IBC), which is based on probabilistic modeling of all seismic sources in the region. King County is working with the USGS SWIFZ researchers and will update the design seismic accelerations for the Brightwater System design if appropriate.

Preliminary explorations indicate that scattered pockets of Vashon Recessional Outwash soils at the Route 9 site have the potential to liquefy during the design seismic event. The large process structures, which would be located in the eastern portion of the site, would generally be founded several feet below the existing ground surface. These structures would be either completely below the Recessional Outwash or at depths where the Recessional Outwash is too dense to liquefy. Therefore, the large process structures located on the eastern portion of the site do not have a liquefaction risk. However, there is a potential for some soils to liquefy beneath the fill that is to be placed on the lower, western portion of the site, and possibly beneath the shallow structures in the middle of the site (the Administration Building, Maintenance Building, and Chemical Building). Detailed liquefaction studies will be performed during final design, based on information from borings drilled at the specific locations of the structures, to determine the potential for liquefaction and to decide on appropriate foundation and soil preparation measures to mitigate the risk of damage. If soil amendments (e.g., soil-cement fills) are used to mitigate liquefaction risks, the mitigations will be designed such that there are no adverse impacts to groundwater or other natural resources.

Settlement Hazards

Settlement is not a critical issue at the Route 9 site. Most of the normally consolidated soils are granular. Settlements, therefore, would be relatively small and would occur almost immediately as the load is applied. Allowable bearing will be adjusted to limit the settlement to tolerable levels in structures founded on the loosest materials at the site.

Soil Contamination

Environmental evaluations conducted in late 2002 and early 2003 indicate a potential for contamination because of past and present activities conducted on portions of the Route 9 site. Current and past industrial activities that could have contaminated these parcels include automotive parts storage, wrecking yards, maintenance shops, a landscaping business, fiberglass boat manufacturing, and utility equipment storage. Storage of petroleum products and hazardous chemicals in tanks, drums, and underground storage tanks, as well as petroleum and chemical releases, have been documented. Some of the parcels have undergone remediation. In addition, these parcels have, or have had, septic systems.

For details about Route 9 site septic systems and industrial activities, see Appendix 4-D, Phase I Environmental Site Assessment—Route 9 Parcels.

Limited information on subsurface soil contamination was obtained from five soil borings drilled in November 2001 (CH2M HILL/Shannon & Wilson, 2002) and five additional borings drilled in early 2003. Field screening with a photo-ionization detector was performed on all cuttings to detect volatile organics. Oil-stained surface soil was observed in various locations around the site. However, field screening did not detect contaminants in any of the cuttings or samples.

If the Route 9 site were to be selected for the location of the treatment plant, King County would further investigate environmental conditions. The investigations would obtain specific information about potential soil and groundwater contamination that would require handling and remediation during construction of the treatment plant

4.2.2.2 Conveyance: Route 9

This section describes the existing geologic conditions that would be potentially affected by the Brightwater conveyance corridors, pump stations, and portal siting areas. Both Route 9 corridor alternatives are discussed together because their topography and geology are similar. The discussion focuses on conditions at portal siting areas because most of the construction activity associated with the conveyance system would take place in these areas.

Maps of surficial geology and geologic hazard areas are presented in Figures 4-1 and 4-3, respectively. Table 4-1 provides specific information on existing earth hazard conditions for each Route 9 conveyance corridor and segment, including portal siting areas. More detailed descriptions of geologic conditions are provided in Appendix 6-B, Geology and Groundwater.

Topography

The Route 9 conveyance corridors cross the north-south topographic grain of the project area, passing eastward across the Intercity Plateau area and then over a series of ridges and valleys. The ground surface elevation along the conveyance corridors ranges from sea level to over 500 feet above mean sea level (MSL).

Geology and Soil Types

Geologic deposits underlying the Route 9 conveyance corridors comprise the same units as previously described in the Regional Geologic Conditions section. Upland areas are underlain predominantly by Vashon Recessional Outwash, Till, Advance Outwash (sand and gravel), and Lawton Clay (glacial lacustrine) deposits. Undifferentiated glacial and nonglacial deposits underlie the Vashon sediments. Valley areas are typically underlain by Vashon Recessional Outwash and Recent alluvium (stream and creek deposits). A detailed discussion of the sediments encountered in the project area is presented in Appendix 6-B, Geology and Groundwater; figures in this appendix show subsurface conditions in cross-section for the 228th Street and 195th Street corridors.

Table 4-1. Earth Hazard Areas on Route 9 Conveyance Corridors

Portal/Tunnel Reach	Mapped Erosion Hazard	Mapped Landslide/Slope Stability Hazard	Seismic Landslide Hazard [a]	Seismic Liquefaction Hazard [b]	Settlement Hazard [c]	Existing Soil Contamination
Route 9–195th Street Corridor						
Primary Portal Siting Areas						
Portal 11	No	No	No	Yes	Yes	Possible – industrial, commercial area
Portal 44	Yes, at east edge	No	Yes	Yes, in southwest corner	Yes	Unlikely – residential area
Portal 41	Yes, at east edge	No	Yes	Yes	Yes	Unlikely – relatively new office development
Portal 5	No	No	No	No	No	Possible - commercial area
Portal 19	No	Yes, east half of portal area	Yes	No	No	Yes – documented contamination at Chevron property
Secondary Portal Siting Areas						
Portal 45	Yes	No	No	No	No	Unlikely – residential area
Portal 7	No	Yes, southwest edge of portal siting area	Yes	No	No	Unlikely – mostly residential area
Portal 27	No	No	No	No	No	Unlikely – mostly residential and cemetery
Portal 23	No	Yes	Yes	No	No	Unlikely – mostly residential area

Table 4-1. Earth Hazard Areas on Route 9 Conveyance Corridors (cont.)

Portal/Tunnel Reach	Mapped Erosion Hazard	Mapped Landslide/Slope Stability Hazard	Seismic Landslide Hazard [a]	Seismic Liquefaction Hazard [b]	Settlement Hazard [c]	Existing Soil Contamination
Route 9–195th Street Corridor						
<u>Tunnel Reaches</u>						
Portal 11 to Portal 44	N/A	N/A	N/A	No, tunnel passes through dense pre-Fraser deposits	Yes	Unlikely, except immediately adjacent to Portal 11.
Route 9 site to Portal 41	N/A	N/A	N/A	No, tunnel passes through dense pre-Fraser deposits	Yes	Unlikely – tunnel 100' to 300' below ground surface
Portal 41 to Portal 44	N/A	N/A	N/A	Yes, tunnel passes through loose alluvium in North Creek valley	Yes	Unlikely – North Creek area relatively recently developed for office park
Portal 44 to Portal 5	N/A	N/A	N/A	No, tunnel passes through dense pre-Fraser deposits	Yes	Unlikely – tunnel generally >100' below ground surface
Portal 5 to Portal 19	N/A	N/A	N/A	No, tunnel passes through dense pre-Fraser deposits	No	Unlikely – tunnel 150' to 350' below ground surface
Route 9–228th Street Corridor						
<u>Primary Portal Siting Areas</u>						
Portal 11	No	No	No	Yes	Yes	Possible – industrial, commercial area
Portal 44	Yes, at east edge	No	Yes	Yes, in southwest corner	Yes	Unlikely – residential area

Table 4-1. Earth Hazard Areas on Route 9 Conveyance Corridors (cont.)

Portal/Tunnel Reach	Mapped Erosion Hazard	Mapped Landslide/Slope Stability Hazard	Seismic Landslide Hazard [a]	Seismic Liquefaction Hazard [b]	Settlement Hazard [c]	Existing Soil Contamination
Route 9–228th Street Corridor						
Primary Portal Siting Areas (cont.)						
Portal 41	Yes, at east edge	No	Yes	Yes	Yes	Unlikely – relatively new office development
Portal 39	No	Yes, at eastern, southern edge	Yes	Yes	Yes	Unlikely – residential and new office parks
Portal 33	No	Yes, at western, northeastern edge	Yes	Yes	Yes	Unlikely – residential area
Portal 26	No	Yes, at western, southern edge	Yes	No	No	Possible – mixed land use near Highway 99
Portal 19	No	Yes, at east half of portal area	Yes	No	No	Yes, documented contamination at Chevron property
Secondary Portal Siting Areas						
Portal 37	No	Yes, at western edge of portal	Yes	No	No	Possible – mixed residential and commercial area
Portal 30	No	Yes, at northern edge of portal	Yes	No	No	Unlikely – mostly residential area
Portal 24	No	Yes, at southern edge of portal	Yes	No	No	Possible – residential, commercial area
Portal 22	No	Yes, at northern edge of portal	Yes	No	No	Unlikely – residential area

Table 4-1. Earth Hazard Areas on Route 9 Conveyance Corridors (cont.)

Portal/Tunnel Reach	Mapped Erosion Hazard	Mapped Landslide/Slope Stability Hazard	Seismic Landslide Hazard [a]	Seismic Liquefaction Hazard [b]	Settlement Hazard [c]	Existing Soil Contamination
Route 9–228th Street Corridor						
<u>Tunnel Reaches</u>						
Route 9 Site to Portal 39	N/A	N/A	N/A	No, tunnel passes through dense pre-Fraser deposits	No	Unlikely, tunnel 60’ to 300’ below ground surface
Portal 39 to Portal 33	N/A	N/A	N/A	No, tunnel passes through dense pre-Fraser deposits	Yes	Unlikely, tunnel 60’ to 370’ below ground surface
Portal 33 to Portal 26	N/A	N/A	N/A	No, tunnel passes through dense pre-Fraser deposits	No	Unlikely, tunnel 100’ to 330’ below ground surface
Portal 26 to Portal 19	N/A	N/A	N/A	No, tunnel passes through dense pre-Fraser deposits	No	Unlikely, tunnel 50’ to 320’ below ground surface

[a] Indicates areas with mapped landslide hazard outside but adjacent to portal siting area.

[b] Based on published maps or visual reconnaissance and geotechnical boring data.

[c] Based on visual reconnaissance and geotechnical boring data.

Data Sources: Sensitive Areas maps folio produced by King County (2003b), GIS data (CDM, 2001), and Snohomish County (2002).

According to federal Soil Conservation Maps for Snohomish County (USDA, 1983) and King County (USDA, 1973), the Route 9 conveyance corridors traverse three major soil series: Alderwood, Everett, and Urban Land Series. The Alderwood group typically forms on glacial till plains; the Everett soils form on terraces or outwash plains; and the Urban Land Series includes soils in nearly level or gently sloping areas covered by streets, buildings, parking lots, and other structures that obscure or alter the local soils.

Geologic Hazards

Many of the local jurisdictions along the conveyance corridors have developed inventories and maps of geologic hazard areas specific to their jurisdictions. Identification of geologic hazard areas summarized in this chapter is based on data provided by the local jurisdiction’s critical areas inventories, a visual reconnaissance completed in early 2003, and the evaluation of geotechnical boring logs.

Erosion Hazards

Figure 4-3 shows areas mapped as having an erosion hazard in the area of the Route 9 conveyance corridors. As illustrated, most of the primary and secondary portal siting areas are outside erosion hazard areas. Portal siting areas are the principal location where construction activities for the conveyance system would occur. Table 4-1 summarizes the erosion hazard at each portal siting area.

Landslide and Slope Instability Hazards

The primary and secondary portals for the Route 9 conveyance corridors are not situated where most previous large landslides have occurred, except in the case of a mapped landslide in Bothell along Bothell Way NE. This slide appears to be a shallow debris flow created by perched groundwater and locally steep slopes. Localized areas of surficial sloughing along short, steep slopes may be present along the project corridors.

Seismic Hazards

Seismic shaking and faulting are discussed under Regional Seismicity. Specific hazards associated with seismic activity are discussed in the following tables:

Ground Rupture

Based on the geology and the distance between the conveyance corridors and the nearest mapped fault zone, the risk of ground rupture within the project area is low.

No published fault lines cross or come within 1 mile of the proposed corridors. A recent unpublished interpretation of data (Troost, 2003) indicates a potential that the SWIFZ could cross the corridors. Designers are working with USGS researchers to determine the following:

- If it is reasonable to assume that faulting could occur across the corridors
- The recurrence interval, magnitude, and displacement associated with surface rupture along the SWIFZ

Liquefaction Potential

The conveyance corridors cross several stream valleys and known areas with liquefaction potential. Areas where liquefiable soils are likely to be encountered are the alluvial deposits in and around North Creek, the Sammamish River, Lyon Creek, Swamp Creek, McAleer Creek, and Little Bear Creek. These alluvial deposits are above the proposed depths of the tunnels, except at North Creek and the Sammamish River.

Seismically Induced Slope Instability

Portal siting areas along segments of the alternative corridors that lie adjacent to steep slopes or near active alluvial environments such as the Sammamish River have a high risk of lateral spreading or flow slides if an earthquake causes liquefaction of the underlying sandy alluvium. Slopes that are marginally stable under static conditions and slopes along the flanks of the prominent ridges throughout the project area may become unstable during a seismic event. Because of the proposed tunnel depths, however, seismically induced slope instability would not cause damage to the tunnels.

Settlement Hazards

Soft compressible soils such as peat or alluvium that occur primarily within stream valleys pose a potential settlement hazard during portal and tunnel construction. Construction dewatering at a portal could potentially cause ground settlement in adjoining areas, and ground and soils removal during tunneling could also cause ground settlement. Table 4-1 summarizes locations of the settlement hazard areas along the Route 9 corridors. The greatest potential for settlement is located where the 195th Street corridor crosses the North Creek valley; peat deposits of significant thicknesses are present in this area.

Contaminated Soil

Nine sites on Washington State's Confirmed and Suspected Contaminated Sites List are located near the Route 9 corridors and portal siting areas. Three sites have been ranked by Ecology and are awaiting remedial action; and one site is awaiting an assessment of site contamination.

Most sections of the Route 9 conveyance corridors pass through residential areas where there is little potential for significant contamination. A few sections pass through areas with commercial or light industrial development, where the potential for contamination is higher. These areas of higher potential for contamination include the influent/effluent corridor near Lake Washington along Bothell Way NE and through the Little Bear Creek valley, and the effluent portions of the corridors in the western part of the project area where they cross or extend along Edmonds Way, NW 205th Street, or other major arterials.

Both the 195th Street corridor and 228th Street corridor pass through the Chevron Richmond Beach Asphalt Terminal property at the Puget Sound shoreline. This property has documented contamination associated with leakage from bulk fuel storage operations. According to investigations completed by Converse Consultants NW (1992), six areas containing free product (termed separate phase hydrocarbons in the report) were identified at the Chevron property. Two of these areas, where product appears to be floating on the water table, are located in the south portion of the property. These areas are (1) the south warehouse area or south seawall area, located near the south end of the wharf, and (2) the decommissioned thinner area, which is located at the foot of the bridge that provides access to the property. Hydrocarbons are described as gasoline, diesel, and motor oil range. Portal Siting Area 19 is the Brightwater System feature closest to the Chevron property and is located approximately 200 to 400 feet from prior environmental explorations.

According to another report prepared by KHM (2001), a groundwater treatment system consisting of four pumping wells along with an oil/water separator, bioreactor tanks, settling tanks, bag filters, particulate filter, and carbon absorber is located in the south seawall area. Treated water from the groundwater treatment system is discharged through an outfall. A Petrobelt skimmer unit removes free product from several of the monitoring wells in the south seawall area. In addition, other monitoring wells in the south seawall area are periodically checked for free product and small volumes are occasionally removed by hand bailing.

Portal 41 Influent Pump Station Option

The affected environment for the Portal 41 influent pump station option is the same as that described for Portal 41 in the Route 9–195th Street corridor in Table 4-1.

4.2.2.3 Outfall: Route 9

Geotechnical and geophysical issues related to outfall construction and operation include topography (for on-land portions of the outfall), bathymetry, slope stability, and soil and/or sediment quality. With respect to the on-land portions of the outfall, these issues are discussed in other sections of this chapter that discuss Portal Siting Area 19 and the

Chevron Richmond Beach Asphalt Terminal site. The location and bathymetry of outfall Zone 7S is shown in Figure 3-9.

Bathymetric surveys (King County, 2001; King County, 2002a; Appendix 4-C, Outfall Geophysical Surveys) indicate a relatively narrow, shallow nearshore shelf with a steeper slope break occurring at a water depth of about -90 to 110 feet MLLW. This low-gradient shelf (the underwater equivalent of a plateau) ranges from about 700 feet wide at the tip of Point Wells to nearly 2,000 feet wide off Richmond Beach. Beyond the shelf, the average seafloor slope increases to approximately 25 percent, with a maximum of approximately 30 to 35 percent. In the northern portion of Zone 7S, the slope is unbroken to about –660 feet mean lower low water (MLLW). In the southern portion of Zone 7S, the slope becomes much more complex, with a second break occurring mid-slope. Between these areas, the slope is relatively uniform at a slope of about 27 percent. The slope transitions to the main channel of Puget Sound approximately 4,000 feet offshore at a water depth of approximately –700 feet MLLW. From this maximum depth, the seafloor rises gradually (at a slope of 5 to 8 percent) before reaching generally flat diffuser areas located between 5,000 and 7,500 feet offshore at water depths of approximately –600 feet MLLW. A side-scan survey indicated that the bottom is free of shipwrecks or other man-made features.

Geophysical sub-bottom profiles (King County, 2001; King County, 2002a; Appendix 4-C, Outfall Geophysical Surveys) encountered a veneer of marine sediments (granular medium-grained soils) over denser, stratified and unstratified sediments of glacial origin. This sediment drape varies in thickness from less than about 5 feet to occasionally more than 20 feet, but tends to be thickest nearest shore and at the slope toe and beyond. Steep submarine slopes mantled with loose, recent granular soils can be susceptible to instability caused by static forces, seismic forces, seismic forces accompanied with liquefaction, and/or construction vibration/disturbance. The sub-bottom data show evidence of historical movement of these surficial marine sediments on the seafloor slope. The deeper soils of glacial origin have a low risk of liquefaction and slope failure. During drilling of a test boring (King County, 2002a), a boulder was encountered at a depth of about 26 feet below the seafloor, and “boulder-like” drilling conditions were reported between depths of 47 and 51 feet in the borehole. The boulder is probably an anomaly but is indicative of features that can be randomly encountered in dense glacial soils.

No sediment quality issues exist beyond those described in Affected Environment Common to All Systems.

4.2.3 Affected Environment: Unocal System

The description of the Unocal site is based on specific geologic and contamination information from the draft remedial investigation conducted at the Unocal site (EMCON, 1998) and the published geologic report by Minard (1985).

4.2.3.1 Treatment Plant: Unocal

The Unocal site consists of one relatively flat to gently sloping area and one moderate to steeply sloped area, referred to as the lower yard and the upper yard, respectively (Figure 4-6). The upper yard includes about two-thirds of the site area; the lower yard comprises the remaining one-third. Surface elevations in the upper yard, which includes the steep slope, range from approximately +25 to +175 feet MLLW. (Note: the MLLW datum is used in place of the commonly used 1988 NGVD because the available site information [EMCON, 1998] used the MLLW datum as its reference. MLLW is approximately 6 feet lower in elevation than NGVD.) Surface elevations in the lower yard range from approximately +10 to +25 feet MLLW. The lower yard wraps around the upper yard's northern edge from the shoreline on the site's western side, along Edmonds Marsh, and then east into a slightly elevated plateau. The slope leading to the upper yard ranges from about 0 to 20 percent grade at the site's northeastern edge to between 40 and 80 percent in the central and western parts of the slope (Figure 4-6). The slope is steepest at its western end.

Geology and Soil Types

In some instances, the description of the Unocal site geology departs from the regional geologic nomenclature described under Impacts and Mitigation Common to All Systems and in Chapter 6. Instead, it uses terms developed as part of the remedial investigation (RI) conducted by the site owner (EMCON, 1998) in response to an Ecology order to investigate soil contamination at the site. The RI included more then 170 subsurface exploratory borings. Four geologic units and two units of fill were defined by EMCON for the site, as described in the following paragraphs.

Lower Yard

The lower yard consists of fill underlain by alluvium and Whidbey Formation deposits. Fill is the uppermost soil material over the entire lower yard. It ranges in thickness from about 1 to 8 feet and consists primarily of loose to medium-dense sand and gravel with small amounts of fine-grained silt and minor amounts of miscellaneous debris such as wood, concrete, wire, and filter fabric (EMCON, 1998). The fill has been geologically mapped as "modified land" (Minard, 1985).

The native soil under the lower yard is identified by the draft remedial investigation as alluvium. It extends to at least the maximum depth explored, about 42 feet bgs, and consists of loose to medium-dense, fine to medium sand with minor amounts of silt, gravel, and organic material and interbeds of silt and sandy silt. The Whidbey Formation may underlie the alluvium, or it may have eroded completely.

Upper Yard

The upper yard consists of fill at the surface, underlain by Lawton Clay, or similar material, and pre-Fraser deposits (Transition Beds), which in turn are underlain by Whidbey Formation deposits. The fill at the surface was placed around tank basins (later demolished) and along access roads. It was reported to range in thickness from less than 1 foot to about 3 feet. Some of the fill has been reworked and regraded as part of the facilities demolition and the soil cleanup program. These are ongoing activities by the site owner, and the final extent of the fill regrading is unknown at this time.

Deposits in the upper yard beneath the fill were mapped by EMCON (1998) as Transition Beds, a geologic term used to describe deposits older than Vashon Advance Outwash but younger than the Whidbey Formation. The Transition Beds are a pre-glacial unit deposited in rivers and lakes in advance of the Vashon glaciers (Minard, 1985). The unit includes Lawton Clay and geologically older, but similar, clay and silt deposits. The Lawton Clay is typically moist, hard silt and clay with occasional fine sand partings. The remainder of the Transition Beds consists of interlayered silt and silty sand with interbeds and lenses of silt. The Transition Beds range in thickness from about 50 to 100 feet beneath the upper yard (EMCON, 1998).

The Whidbey Formation underlies the Transition Beds (Lawton Clay and pre-Fraser deposits) in the upper yard and consists of very dense medium- to coarse-grained sand with varying amounts of gravel and silty sand and interbeds and lenses of silt. The draft RI shows the contact between the pre-Fraser deposits and the Whidbey Formation to be approximately +18 feet MLLW. The base of the unit was not encountered in the RI explorations.

Geologic Hazards

Crustal Bending or Folding

Concerns were expressed during EIS scoping about the possible presence of a geologic or structural feature near the Unocal site, particularly a feature called the Kingston Arch. An “arch” is a geologic structural feature that differs from a fault in that it indicates bending or folding rather than earth slippage or movement. The domed, or arched, Kingston Arch has been mapped using geophysical techniques that locate the top of bedrock. Brocher et al. (2001) suggest that this geologic feature may still be bending or folding, but also note that available data do not clearly indicate the presence of resulting shallow crustal faults. Arches or anticlines, which are present throughout the Puget Sound area and the world, are not known for earthquake activity. Rather, they represent past compression and folding of the rock. Much more concentrated areas of microseismic activity have been observed along the Tacoma Fault Zone and Seattle Fault Zone, where offsets of several thousand feet are interpreted from geophysical data.

Figure 4-2 shows the approximate locations of the Kingston Arch, South Whidbey Island Fault Zone, and Seattle Fault Zone. The trendline of the Kingston Arch is about 3,700 feet north of the Unocal site.

Liquefaction Potential

Soil in the lower yard presents a potential liquefaction hazard. The soil in the upper yard are of the Unocal site and does not present a liquefaction hazard. When subjected to sustained seismic shaking, the soil in the lower yard area, (loose, saturated, fine- to medium-grained sand with minor amounts of silt) has the potential to temporarily lose its shear strength, resulting in a quicksand-like condition. As a result, lateral spreading (ground movement) may occur. Soil bearing capacity and lateral support to structures, which the soil typically provides, may be significantly reduced under these conditions. The lower yard has relatively high seismic accelerations and a high water table, and therefore loose, sandy soil on the site has the potential for liquefaction. Figure 4-7 shows the inferred boundary of the liquefaction hazard area of the Unocal site.

Contaminated Soil

The Unocal site is a state-listed hazardous site with a Washington Ranking Method rank of 1, the highest ranking for cleanup. The site owner, Unocal, is cleaning up the site with oversight by Ecology under an Agreed Order between the two parties. The remedial action is in progress under the Model Toxics Control Act. Cleanup of the upper yard was completed in March 2003, and a final cleanup report is being prepared. Ecology will select the cleanup actions for the lower yard.

The site is contaminated from past uses that involved storing, blending, and distributing petroleum products, including gasoline, diesel fuel, and bunker fuel. In addition, an asphalt plant operated at the site between 1953 and the late 1970s. Contamination has been detected in the soil. Additional detail about contamination is contained in Appendix 6-B, Geology and Groundwater.

Unocal conducted an interim remedial action in 2001 that consisted of excavation and offsite recycling, treatment, and disposal of free petroleum product and associated petroleum-contaminated soil from four areas in the lower yard. The excavations were brought up to grade with clean, imported quarry spalls and gravel.

At this time, the extent of soil removal or cleanup measures that Ecology may require for the lower yard is unknown. Final cleanup of the lower yard is projected to begin in summer 2005 (Washington State Department of Ecology (Ecology), 2003; Edmonds, 2002).

4.2.3.2 Conveyance: Unocal

Geology, topography, and geologic hazards for the Unocal corridor are similar to those of the Route 9 corridors. Maps of surficial geology and geologic hazard areas along the conveyance corridors are presented in Figures 4-1 and 4-3. Table 4-2 provides specific information on existing conditions for the Unocal conveyance corridor and segments, including portal siting areas. More detailed descriptions of geologic conditions are provided in Appendix 6-B, Geology and Groundwater.

Geology and Soil Types

Geologic deposits along the Unocal corridor are similar to those described for regional conditions and the Route 9 conveyance corridors. The primary difference is that compared to the other corridors, the eastern half of the Unocal influent tunnel would be closer to the surface and would extend through a larger proportion of loose alluvial sediments along the northern edge of Lake Washington and in the Sammamish River and North Creek valleys. To the west, the Unocal influent tunnel would deepen and pass through a sequence of dense, mostly pre-Fraser glacial and nonglacial sediments, similar to the other conveyance lines.

Geologic Hazards

The Unocal conveyance corridor is shorter than either of the Route 9 corridors, has fewer potential portal locations, and thus presents fewer geologic hazards. However, these fewer hazards are offset by a generally greater liquefaction and settlement potential. Table 4-2 summarizes the Unocal conveyance corridor hazard areas.

4.2.3.3 Outfall: Unocal

Geotechnical and geophysical issues related to outfall construction and operation include topography (for on-land portions of the outfall), bathymetry, slope stability, and soil and/or sediment quality. With respect to the on-land portions of the outfall, these issues are discussed in sections of this chapter that discuss the Unocal treatment plant site. The location and bathymetry of outfall Zone 6 is shown in Figure 3-21.

The nearshore shelf of Zone 6 extends approximately 950 feet offshore. Beyond the shelf, the average seafloor sideslope increases to approximately 15 percent, with a maximum of approximately 20 percent. The sloped seafloor transitions to the main channel of Puget Sound approximately 5,000 feet offshore at a water depth of approximately –600 feet MLLW.

Geophysical surveys (King County, 2001; King County 2002a) indicate that a veneer of marine sediments (granular medium-grained soils) overlie pre-Vashon nonglacial, estuarine and fluvial sediments. Steep submarine slopes mantled with loose, recent granular soils can be susceptible to instability caused by static forces, seismic forces, seismic forces accompanied with liquefaction, and/or construction vibration/disturbance. Eroded soil on mid and upper steep-slope areas may be evidence of a previous submarine slide. The deeper soils of pre-glacial origin have a lower risk of liquefaction and slope failure.

No sediment quality issues exist beyond those described in Affected Environment Common to All Systems.

Table 4-2. Earth Hazard Areas on the Unocal Conveyance Corridor

Portal/Tunnel Reach	Mapped Erosion Hazard	Mapped Landslide/Slope Stability Hazard	Seismic Landslide Hazard [a]	Seismic Liquefaction Hazard [b]	Settlement Hazard [c]	Existing Soil Contamination
Primary Portal Siting Areas						
Portal 14	No	No	No	Yes	Yes	Unlikely – relatively new office development
Portal 11	No	No	No	Yes	Yes	Possible – industrial, commercial area
Portal 7	Yes	Yes	Yes	No	No	Unlikely – mostly residential
Portal 3	No	Yes, at southern edge	No	No	No	Possible – mixed commercial, residential area
Secondary Portal Siting Areas						
Portal 13	No	No	Yes	Yes	Yes	Possible – commercial area
Portal 12	No	No	Yes	Yes	Yes	Unlikely – low density residential area
Portal 10	No	No	Yes	Yes	Yes	Possible – mixed commercial, residential area
Portal 5	No	No	No	No	No	Possible - commercial area
Tunnel Reaches						
Portal 14 to Portal 11	N/A	N/A	N/A	Yes, tunnel passes through North Creek alluvial deposits	Yes	Possible – tunnel shallow near Portals 11 and 14
Portal 11 to Portal 7	N/A	N/A	N/A	Yes, tunnel passes through alluvial deposits	Yes	Possible – tunnel shallow across north end of Lake Washington
Portal 7 to Portal 3	N/A	N/A	N/A	No	No	Unlikely – tunnel 110’ to 190’ below ground surface
Portal 3 to Unocal Site	N/A	N/A	N/A	No	No	Yes – documented contamination at Unocal site, unlikely elsewhere

[a] Indicates areas with mapped landslide hazard outside but adjacent to portal.

[b] Based on published maps or visual reconnaissance and geotechnical boring data.

[c] Based on visual reconnaissance and geotechnical boring data.

Data Sources: Sensitive Areas maps folio produced by King County (2003b), GIS data (CDM, 2001), and Snohomish County (2002).

4.3 Impacts and Mitigation

In this section, impacts that are common to all treatment plant sites, conveyance corridors, and outfall zones are described first; then impacts that are specific to each alternative are described. For the common impacts discussion, issues related to the treatment plant and conveyance system are grouped together. For the specific mitigation options, the treatment plant and conveyance corridors are discussed separately.

4.3.1 Impacts and Mitigation Common to All Systems

4.3.1.1 Construction Impacts Common to All Systems

Construction activities that may affect the earth environment are summarized in Appendix 3-G. Construction of the treatment plant will include soil excavation and fill placement using cranes, bulldozers, and other mechanized equipment. Some of the excavation and fill placement will occur on sloping areas and in areas subject to settlement or liquefaction. Construction of a deep influent pump station requiring specialized construction techniques is proposed for the Route 9 site and is discussed in more detail under Impacts and Mitigation: Route 9 System and in Appendix 6-B, Geology and Groundwater.

For the plant sites, activities with earth-related impacts include clearing, grubbing, dewatering, earthmoving, and construction of earth-retention structures. All of these activities have the potential to cause erosion, either by exposing soil to precipitation and runoff or, in the case of dewatering, by concentrating water flow. Earthmoving is required to excavate for structure, pipe, and drainage facility construction and involves the issue of soil reuse onsite versus offsite haul and disposal, possibly with import of special backfill materials. All the activities listed have the potential to distribute contaminated soil or groundwater to previously uncontaminated areas if contamination exists and is not properly remediated. If not properly conducted, excavation and filling have the potential to decrease the stability of slopes, and could result in landsliding. Finally, vibrations from pile installation and heavy equipment operation have the potential to damage nearby structures.

For the conveyance systems, most of the observable construction activities that could potentially have earth-related impacts would take place during construction of connections to existing systems and at the primary portals, specifically the launching (or working) portals. This is because the tunnel boring machine (TBM) is assembled and started from the launching portal, and the tunneling operation must be maintained by work performed at ground surface around this portal. The recovery portals would see less activity, because they would be used primarily to retrieve the TBM from completed tunnel segments. Earth-related hazards associated with tunneling activities would be limited primarily to settlement and seismically induced liquefaction.

Some construction activities could also take place at secondary portals, although it is not anticipated at this time. Secondary portal sites, if used, are considered only to allow ground improvement at depth to facilitate TBM maintenance or to provide ventilation to the tunnel (after the TBM has passed). The construction methods used to provide either ground improvement or ventilation shafts involve drilling using cased boreholes, similar to the type of drilling used to perform geotechnical explorations. The methods would not involve bulk excavation. Based on the current understanding of the geology, secondary portals would likely not be required for ground improvement purposes.

The following four primary activities associated with construction of the conveyance system pose the potential for earth impacts:

- **Site preparation for local connections and at portals.** Site preparation would including clearing, grading, fencing, and preparation of construction support facilities.
- **Primary portal construction.** Portal construction would focus on installing a temporary vertical shaft extending from the ground surface to the tunnel elevation. It is anticipated that initial support systems for the portal would consist of pre-installed structures such as diaphragm (slurry) walls, interlocking sheetpiles, or ground freezing. Table 4-3 summarizes anticipated geologic conditions at each portal and associated construction methods. Equipment and material deliveries would continue during construction of permanent portal facilities.
- **Tunnel excavation and lining.** During tunnel construction, support would be provided by cranes and other earthmoving equipment and by regular truck visits to remove excavated material from the site and to deliver the pre-cast tunnel lining and other materials. Microtunneling and open-cut construction methods may be used for constructing smaller pipelines that connect to the existing conveyance system.
- **Connections to existing system.** Construction would include excavation of pipe trenches and jacking pits using conventional construction equipment.

Based on the planned methods and facilities described above and in Chapter 3, potential construction impacts common to all system alternatives are summarized in Table 4-4 and include the following:

- Erosion
- Excavated soil reuse and offsite haul
- Contaminated soil and groundwater
- Landslide hazard
- Vibration and settlement

Table 4-3. Anticipated Geologic Conditions and Construction Methods at Primary Portal Siting Areas on the Route 9 and Unocal Conveyance Corridors

Corridor	Portal Number	Estimated Portal Diameter (ft)	Estimated Portal Depth (ft)	Anticipated Geologic Conditions	Anticipated Construction Method
Route 9–195th Street	19	50	40	0-58[1] med to dense SAND & GRAVEL; 58[1]-78[1] hard SILT; 78-140 dense to v dense SAND & GRAVEL	Interlocking steel sheetpiles / Jet-grouted bottom plug
	5	30	180	0-68[1] loose to v dense SAND, 68[1]-256[1] v stiff to hard CLAY, 256[1]-279[1] GP; 279[1]-322[1] v stiff CLAY; 322[1]-347[1] v dense SAND; 347[1]-360[1] v stiff to hard CLAY	Concrete caisson or concrete slurry walls to 75', followed by sequential excavation and concrete lining to invert
	44	50	80	0-40 med dense to v dense silty, clayey SAND;40-55 hard SILT;55-105 dense to v dense SAND; 105-133 v dense GRAVEL	Concrete slurry wall / Jet-grouted bottom plug, open sump
	41	50	90	0-19 med dense silty SAND; 19-21 hard SILT; 21-86 med dense to dense silty SAND	Concrete slurry wall / Jet-grouted bottom plug, open sump
	11	50	45	0-23 med dense silty SAND; 23-27 v stiff CLAY; 27-45 m to v dense silty SAND;45-57 hard SILT; 57-85 v dense SAND; 85-90 hard SILT	Interlocking steel sheetpiles, open sump
Route 9–228th Street	11	50	45	Same as 195th Street corridor	Same as 195th Street corridor
	44	50	80	Same as 195th Street corridor	Concrete slurry wall / Jet-grouted bottom plug, open sump
	19	50	40	Same as 195th Street corridor	(1) Interlocking steel sheetpiles / Jet-grouted bottom plug
	26	30	200	0-172 v dense silty SAND; 172-262 hard CLAY; 262-292 v dense silty SAND; 292-363 hard CLAY	Ground freezing
	33	50	100	0-126 med dense v dense SILT & SAND; 126-194 hard CLAY; 194-246 v dense silty SAND;246-362 hard CLAY	Concrete slurry wall to 130' bgs into CLAY / Open sump
	39	50	110	0-82 loose to v dense silty, clayey SAND; 82-122 hard CLAY	Concrete slurry wall / Open sump
	41	50	90	Same as 195th Street corridor	Concrete slurry wall / Jet-grouted bottom plug, open sump
Unocal	7	50	120	0-28 med. dense/dense SP; 28-86 v stiff/hard ML; 86-181 v stiff to hard SILT; 181-215 v stiff CLAY and SILT; 215-297 hard CLAY	Concrete slurry wall / Open sump
	3	30	280	0-202 med dense silty SAND; 202-232 hard CLAY; 232-254 dense silty SAND; 254-295 hard CLAY; 295-369 med - v dense silty SAND	Ground freezing
	11	50	60	Same as 195th Street corridor	Same as 195th Street corridor
	14	30	50	0-17 med dense silty SAND; 17-27 v soft CLAY; 27-96 med dense silty SAND	Interlocking steel sheetpiles / Open sump

v = very med = medium

Table 4-4. Potential Earth Impacts and Proposed Mitigation Common to All Systems

Potential Impact	Description of Potential Impact	Mitigation
Construction Impacts		
Erosion	Erosion can result from removal of vegetation, fill placement, or stockpiling. Erosion can contribute to water degradation by discharge of silt-laden runoff into local surface water sources or storm sewers.	Best Management Practices will be required of the construction contractor during earthwork activities. Monitoring programs will be required to ensure compliance with local regulations.
Excavated soil reuse and offsite haul of unsuitable soil	“Cut-and-fill balance" of plant layouts and physical properties of excavated soil will affect the amount of excavated soil that can remain onsite for structural backfill and general site fill; excess excavated soil will need to be hauled offsite for disposal.	Plant site layouts will be optimized to provide an acceptable cost-benefit outcome between the layout configuration and offsite disposal quantities. Incentives will be provided to construction contractor, and contract specifications would include reuse of as much excavated material as possible, thus reducing offsite haul trips.
Contaminated soil	If contaminated soil is encountered, there would be the potential for risks to workers and for release of contaminants to air and to non-contaminated areas.	Construction specifications will include provisions for monitoring soil during excavation activities, for handling and disposing of contaminated soil if encountered, and for required upgrades to worker personal protection equipment as appropriate.
Landslide hazard	Slope movement could result in increased erosion and sedimentation with possible reduction of surface water quality. Extreme cases could endanger offsite property.	Design that considers global stability of temporary excavations and controls on temporary slopes would substantially reduce risk.
Vibration and settlement	Vibration and settlement increases the risk of slope movement and its associated hazards. Potential to damage adjacent structures and utilities.	Specifications, submittal processes, and construction oversight will limit vibrations as described in Chapter 10. Appropriate design measures will be incorporated to reduce settlement where it could damage adjacent facilities, and settlement monitoring will be conducted.
Operation Impacts		
Erosion	Unpaved surfaces present a long-term erosion potential.	Vegetation would be maintained and adequate surface water runoff controls provided.
Contaminated soil and Groundwater	Chemical spills or leaks could potentially contaminate surface soils during treatment plant and conveyance system operation. Leaky process basins or pipes could introduce contamination to soil and groundwater	Spill prevention control procedures and plans will be prepared in accordance with regulations. Secondary contaminant for tanks and controlled drainage in areas subject to spills or leaks would be provided. Design will incorporate extra steel, waterstops, flexible couplings. Construction will require quality control actions and hydrostatic testing. Leak detection system would be installed on all process structures with an outward hydraulic gradient.
Landslide hazard	Slope movement could result in increased erosion and sedimentation with possible reduction of surface water quality. Extreme cases could endanger offsite property.	Design that considers global stability of permanent excavations and walls would substantially reduce risk.
Seismic hazard	Liquefaction could damage facilities, reducing surface water quality and effluent quality.	Design will consider liquefaction and improve the soil so it cannot liquefy beneath critical structures.

Earth conditions described for individual 72-acre portal siting areas are generalized, based on available regional-scale maps and on a visual site reconnaissance of accessible areas. Comparison of earth hazards among candidate portal sites within portal siting areas is not possible without additional access and site-specific geologic and geotechnical explorations. Consequently, individual candidate sites are not discussed in this chapter, but are addressed within the context of the larger 72-acre portal siting areas.

Erosion

Uncontrolled stormwater runoff during construction could result in sediment-laden surface water from erosion of disturbed, stockpiled, or unvegetated soil areas in any of the system alternatives. In the work zone, construction would expose soil and remove vegetative cover, leaving the area vulnerable to erosion during runoff events. Construction spoils generated from tunneling actually would be returned to the surface in a semi-solid form, which would be stockpiled onsite prior to being trucked offsite. This stockpiled material could present an erosion hazard, if uncontrolled. Sediment that reaches adjacent surface water resources could possibly lead to increases in turbidity, suspended and settleable solids, and nutrients, which may be detrimental to fish and other aquatic organisms. However, the construction specifications and drawings will dictate requirements for erosion and sedimentation control so that no sediment would reach surface water sources if the contract provisions are correctly implemented.

Figure 4-3 shows erosion hazard areas, where the risk of erosion is particularly high; Tables 4-1 and 4-2 list the particular hazard areas that occur along the conveyance corridors. The potential erosion hazard is highest for the Route 9–228th Street corridor because is has the greatest number of potential portals (seven primary; up to four secondary), followed by the Route 9–195th Street corridor (five primary; up to four secondary) and the Unocal alternative (four primary; up to four secondary).

Excavated Soil Reuse and Offsite Haul

The export and import earthwork quantities for each of the system alternatives, including the connections to the existing system (local connections), are identified in Table 4-5.

A “cut-and-fill balance” was calculated for each of the treatment plant sites to determine whether and how much soil would need to be imported to enable construction and backfilling around the structures, and whether and how much excess soil would need to be hauled offsite for disposal. Factors that affect the need to import or export soil include the site topography, facility layout, depth to which structures are to be buried into the ground, and suitability of excavated soil for retention as backfill or grading fill. A portion of the soil excavated from treatment plant sites and nearly all excavated soil from portal and tunnel sites will need to be hauled away for offsite disposal.

Offsite disposal is estimated as 1.6 million cubic yards at the Unocal site and about 340,000 cubic yards (truck measure, which includes a 25 percent swell factor) at the Route 9 site. Additional earth would be excavated for creation of stormwater treatment ponds. Soil from excavation of stormwater ponds would be used to create berms and grading in the vicinity of the ponds and would not be trucked offsite. If the Route 9 site is selected and the influent pump station is moved from Route 9 to Portal Siting Area 41, the offsite disposal from Route 9 would be reduced by 170,000 cubic yards; additional offsite disposal from Portal Siting Area 41 would be increased by 37,000 cubic yards.

Soil excavated for construction of the primary portals and tunnels would be generated at each primary portal location, the majority of which would be produced at the launching portals where the excavated tunnel soil is discharged. Excavation volumes are estimated to be between 588,390 and 911,040 cubic yards for the conveyance alternatives. Soil additives such as bentonite, polymers, and foams may be used to condition the soil during tunneling, but typically the conditioned soil does not require special disposal. More detailed estimates of volume for each alternative are presented in following sections.

Table 4-5. Estimated Soil Export and Import Quantities for All Systems

Earthwork Activity	Route 9–195th Street (cubic yards)	Route 9–228th Street (cubic yards)	Unocal Alternative (cubic yards)
Soil Export			
Plant Site	340,000*	340,000*	1,600,000
Conveyance	911,040	755,040	588,390
Outfall	30,000	30,000	31,000
Total soil export	**1,281,040**	**1,125,040**	**2,219,390**
Soil Import			
Plant Site	120,000	120,000	500,000
Conveyance	0	0	0
Outfall	29,000	29,000	29,700
Total soil import	**149,000**	**149,000**	**529,700**

cy = cubic yards by truck measure.
Conveyance quantities are for tunnel and portals combined, plus connections to the existing system.
*Includes IPS at Route 9 plant site.

Excavation volumes for the secondary portals, if used, could be up to 600 cubic yards each. Excavation volumes for the Kenmore local connections, which are common to all alternatives, would be approximately 1,790 cubic yards.

Hauling and disposing of soil offsite would increase truck traffic to and from the treatment plant sites and primary portal sites during construction. The potential impact of increased traffic volumes from importing or exporting soil is evaluated in Chapter 16.

The soil excavated for any of the conveyance alternatives represents a significant volume of soil that would require disposal or use. The contractor will be responsible to propose disposal methods for review and approval by King County in accordance with the project specifications and local permitting requirements. Most of the excavated soil is expected to be uncontaminated and available for unrestricted reuse. Contaminated soils, if encountered, will be handled in accordance with a contingency plan developed by the contractor in accordance with the project specifications and Ecology regulations.

Contaminated Soil and Groundwater

Construction activity may result in potential contamination of soil if chemical spills (such as fuels and lubricants) were to occur. The potential for the contaminants to impact the soil would depend on the nature and quantity of the spill, time between the spill and the clean-up, depth to groundwater, and geology of the area. Tunneling and drilling fluids consisting of either bentonite or polymers may temporarily change groundwater quality in the immediate vicinity of the tunnel face or bore, as discussed in Chapter 6.

If soil and groundwater contamination is encountered during construction, it will be mitigated and addressed in accordance with local, state, and federal regulations. The Unocal site is a state-listed hazardous waste site with known soil and groundwater contamination and is currently being remediated by the site owner. Past and present uses of the site indicate that contaminants may be found at the Route 9 site. Any contamination discovered within the depths excavated would be treated on-site or disposed of, or treated offsite at an approved facility.

Tables 4-1 and 4-2 summarize the potential for existing contamination along the Route 9 and Unocal corridors. The Unocal corridor generally passes through more areas with higher contamination potential as compared to the Route 9 corridors.

Landslide Hazard

Excavations into or at the base of landslide hazard areas are proposed in all system alternatives. Improper design or construction could result in ground movement that could extend beyond the site boundaries, with resulting soil disturbance. The risks and consequences of failure are judged to be somewhat higher at the Unocal site as compared to the Route 9 site because of the high slopes and limited space. Of the three conveyance corridors, the Route 9–228th Street corridor has the highest number of portal siting areas that encroach into mapped landslide hazards (see Figure 4-3).

Vibration and Settlement

Construction methods for conveyance may result in vibration and settlement that could damage adjacent structures. These methods include excavations for portals, installation of driven piles, tunneling, microtunneling, jacking and boring, and open-cut construction, as summarized in Table 4-3.

The risk of minor damage to nonhistoric residences is identified as 5 percent with a peak particle velocity (PPV) of 1.8 inches per second. The PPV dampens with distance from the source (construction equipment). At a distance of 400 feet from typical pile driving hammers, the PPV is below this potential damage limit; therefore, the potential for vibration-induced problems is slight (also see Chapter 10).

Ground settlement could potentially occur at primary portal locations primarily through groundwater withdrawal during construction. The greatest potential, as summarized in Tables 4-1 and 4-2, occurs at portals located within stream valleys where the water table is close to land surface, specifically Portal Siting Areas 11, 14, and 41. Higher groundwater extraction rates are expected at these portals. Current construction plans for the other portals include limited dewatering, as described in Chapter 6 and in Appendix 6-B, Geology and Groundwater. Consequently, little or no settlement would occur at these other portals.

Ground settlement may also occur during tunneling as the result of soil removal and flow of groundwater into the tunnel. The settlement potential is greatest immediately above the tunnel center line and decreases outward. Settlement effects extend outward typically no more than three tunnel diameters, or less than 100 feet for the Brightwater tunnels. The greatest potential for settlement resulting from soil removal is where the tunnel is closest to land surface and in loose alluvial sediments. These conditions occur in the stream valleys in the eastern portion of the Brightwater project area and near Lake Washington. Groundwater settlement during tunneling as the result of groundwater inflow is not expected to be a significant hazard because of the limited flow volumes expected, as described in Chapter 6 and Appendix 6-B. The Unocal corridor has a slightly higher potential for settlement compared to the other corridors because of the greater proportion of the tunnel that would be shallow and in alluvial sediments.

4.3.1.2 Operation Impacts Common to All Systems

Operational activities at the plant sites that present the potential for earth-related impacts are discussed in following sections. Operation of the conveyance system would not generally be subject to earth-related impacts because most of the system comprises pipelines that “passively” convey fluids and because operations at the permanent portal facilities would primarily involve monitoring and sampling. Somewhat greater maintenance and operations activities would occur at the conveyance dechlorination facility and odor control facilities.

Potential earth-related operation impacts common to all systems include the following:

- Erosion
- Landslide hazard
- Seismic hazard (liquefaction-susceptible soil, pipe rupture)

These impacts are described in Table 4-4.

Erosion

Sediment erosion into surface water can occur during the operational life of the Brightwater Treatment Plant and at individual portal facilities if stormwater runoff is not controlled. Erosion potential would be reduced by maintaining vegetation and providing adequate runoff controls in accordance with state and local regulations and approval. Facilities plant will be designed to incorporate all required measures to control and treat stormwater runoff. The design would specify that site surfaces be either paved or revegetated (with a native grass seed mixture or hydroseeded with a seed-mulch-fertilizer mixture) as soon as practical following achievement of desired grades in order to minimize or prevent long-term erosion that could degrade local water quality.

Landslide Hazard

The deepest shear plane (area where the soil failure occurs) of most landslides is at an elevation near or slightly below the base of slope. Because the conveyance tunnels would pass well below the base of hillside slopes, there would be no appreciable risk associated with tunnels passing through landslide hazard areas. Tunnel portals in landslide hazard areas have a risk of being covered or damaged if a landslide were to occur, but would be engineered and constructed to manage landslide risk. Tables 4-1 and 4-2 summarize landslide hazard areas by corridor.

Seismic Hazard

Loose, saturated, cohesionless soil located in the lower yard of the Unocal site and in some areas of the Route 9 site may be susceptible to liquefaction during earthquake events. As described in the Affected Environment section, liquefaction can result in differential settlement and damage to structures with shallow foundations and to utilities, embankments, and pavement. Figures 4-5 and 4-7 show the areas of the Route 9 and Unocal sites, respectively, that are believed to be susceptible to liquefaction. Tables 4-1 and 4-2 summarize the number of potential liquefaction hazard areas at each of the conveyance corridors.

Tunnels and portals that are located in loose, saturated sediments typically present in the North Creek and Sammamish River valleys and along the edge of Lake Washington are potentially subject to liquefaction. Some liquefiable sediments also exist at portal siting areas in other stream valleys. Tunnel segments and portals outside of these areas would be founded in dense, overconsolidated deposits not generally subject to liquefaction.

As noted previously, published information indicates that there is no surface expression of ground faulting within 1 mile of any of the conveyance alignments. Recent, unpublished interpretations of data (Troost, 2003) indicate a potential for some of the SWIFZ lineaments to pass across all the conveyance alignments. If present and if a fault rupture were to occur, it could damage the pipeline and groundwater could drain into the pipeline under hydrostatic heads ranging from 50 to 250 feet. Brightwater designers are working with researchers from the USGS and the University of Washington to incorporate the most current interpretations and data into the Brightwater System design. The recurrence interval for the SWIFZ is thought to be about 1,000 years, much longer than the 500-year recurrence interval commonly used for wastewater treatment plants. In addition, because faulting occurs through a zone, the location of a possible surface rupture is unpredictable, if it will occur at all.

4.3.1.3 Proposed Mitigation Common to All Systems

Proposed mitigation measures common to all systems are discussed below are summarized in Table 4-4.

Construction Mitigation Common to All Systems

All of the impacts related to existing geologic hazard areas can be mitigated by identifying the hazard during predesign, designing for the hazard, and applying appropriate codes and Best Management Practices (BMPs) as described below. Portals would be located within portal siting areas in a manner that avoids hazard areas to the extent possible.

Erosion

Mitigation measures for erosion and sedimentation control that are suitable for the site conditions would be included as part of the project design and construction to minimize sediment-laden runoff and windblown dust. A comprehensive erosion and sediment control plan would be required by county and local municipalities before construction begins. At a minimum, the plan would include elements for the following:

- Disturbed earth surfaces
- Protection of slopes and soil stockpiles
- Protection and stabilization of drainageways
- Retention of sediment

All construction activity would be required to use BMPs to minimize erosion and sedimentation impacts. BMPs include commonly specified and implemented features that are mandated by King County, Snohomish County, and local municipality guidelines as well as additional measures deemed appropriate for the project. The project would also be required to comply with conditions of the NPDES stormwater permit for construction.

BMPs that may be used to control construction-related runoff and erosion include the following:

- Maintaining vegetative growth and providing adequate surface water runoff systems
- Limiting the amount of area that is cleared and graded at any one time, and scheduling construction activities soon after an area has been cleared and stripped of vegetation
- Constructing temporary siltation/sedimentation ponds to detain runoff waters and trap sediment from erodible areas
- Revegetating or paving disturbed areas as soon as possible after completion of construction, as discussed in Chapter 6
- Covering soil stockpiles with plastic sheeting and weights
- Placing straw, mulch, or commercially available erosion control blankets on slopes that require additional protection
- Placing straw bales or silt fences to reduce runoff velocity in conjunction with collection, transport, and disposal of surface runoff generated in the construction zone

During construction, monitoring programs will be required to measure the contractor's compliance with the site erosion control plan and with local regulatory requirements. The construction contractor, with quality assurance from the owner and the local jurisdiction, will measure parameters such as turbidity, temperature, and pH of surface water discharge and will visually monitor the site for signs of erosion and implementation of control measures.

Excavated Soil Reuse and Offsite Haul

Approaches to minimize the amount of soil hauled offsite include (1) treating excavated soil onsite (for example, by adding a small percentage of cement) to allow reuse of otherwise unacceptable excavated material (soil that is too wet and contains too much silt and clay) as site fill, and (2) optimizing plant layouts and the depth to which structures are buried beneath the ground surface. The tradeoffs between locating many of the facilities below grade in order to reduce visual impacts and the increased offsite haul generated by the additional excavation for these below-grade structures will be evaluated as design progresses. The offsite haul would be reduced as much as possible, by using excess excavated material for landscaping berms and general site fill at a distance from process buildings.

Contaminated Soil and Groundwater

The construction specifications and plans would require contractors to apply BMPs at all construction sites, thereby reducing the risk of spills and minimizing the effects of spills if they do occur. In addition, the construction documents would require a spill prevention plan, stormwater pollution prevention plan, and hazardous waste contingency plan specific to the contractor's proposed construction methods, all of which address the handling of hazardous materials. The spill prevention and stormwater pollution prevention plan would follow guidelines developed by Ecology. Contaminant and regulatory experts would develop the hazardous waste contingency plan, tailored to the past history of the site and the findings of the ongoing site assessments.

King County will comply with hazardous waste regulations (Model Toxics Control Act rules per Chapter 173-340 WAC) and standard procedures to determine the nature and extent of contamination. This may include conducting environmental site assessments and hazardous material surveys prior to right-of-way acquisition or construction of pipeline segments. A hazardous substance management plan would be prepared to specify procedures, including identification, storage, and disposal, for work in areas where contaminated soil could be encountered. Other mitigation measures could include the following:

- Identifying utilities that need to be relocated. Electrical transformers containing oil, considered a hazardous substance under state regulations, would be handled carefully to avoid a release or accidental spill during the relocation of transformers.
- Performing detailed site assessments, which could include a review of existing environmental conditions with a focus on the potential for offsite contamination by groundwater.
- Testing subsurface conditions at selected sites within the conveyance corridor to determine the presence and character of soil contamination, phasing construction with cleanup activities to avoid contaminated areas for those sites currently undergoing cleanup, and coordinating with responsible parties and regulatory agencies.
- Implementing a program of on-call inspection and testing of areas of suspected contamination during construction. This program would prevent the transport of contaminants, if present, to uncontaminated areas and provide for proper treatment or disposal of contaminated material.
- Requiring contractors to use construction practices that minimize the risk of hazardous material spills from routine operation of construction equipment. The contractor would prepare a spill prevention plan and designate an onsite emergency coordinator. The contractor would also be familiar with proper

hazardous material storage and handling procedures and emergency procedures, including proper spill notification and response requirements.

- Preparing a contingency plan for encountering contaminated soils, such as sufficient stockpile areas for contaminated soils. Excavated soils may be classified as "hazardous wastes" if they contain sufficient chemical contamination to be classified as a "dangerous waste mixture" under the Washington State Dangerous Waste Regulations (WAC 173-303).

Landslide Hazard

Measures that would substantially reduce the risk of landsliding include (1) static and seismic loading design that considers the potential for strain softening (soil strength loss over time) of lacustrine soils, and (2) construction specifications and quality assurance programs that prohibit oversteepened slopes. Design of permanent slopes will be in accordance with local industry standards that provide for a minimum factor of safety for static global stability of 1.5 and a minimum factor of safety for seismic stability of 1.1. Global stability considers the possible movement, over a variety of sliding surfaces, of an entire hillside, including any engineered structures on the hillside.

Permanent structures will be designed to withstand lateral earth loading from static and seismic loading. Seismic accelerations and structural design will be based on the 2003 IBC.

Vibration and Settlement

Mitigation for the potential impacts due to vibration and settlement would include pre- and post-construction surveys of adjacent structures and a construction monitoring program. If existing structures would be close enough to be damaged by vibrations or undermined by excavations or if soils would be sensitive or subject to settlement when dewatered, additional mitigation would include underpinning structures, installing recharge wells (for dewatering), modifying construction techniques (such as choice of pile type, installation equipment, or tunneling method), or using displacement grouting so that adjacent facilities are not damaged. Re-leveling and repair would be used as contingency measures.

If the engineer determines that pile installation or heavy equipment operation would occur close to existing structures, adjacent at-risk structures would be monitored so that vibrations are kept below a maximum peak particle velocity, to minimize the risk of damage. (The engineer would base this determination on published measurements of vibration and attenuation with distance for various equipment and on personal experience.) Vibrations and settlement can be greatly reduced or eliminated by carefully selecting construction methods and equipment. The specific impacts on adjacent properties would be analyzed during the final design stages of the project.

After a corridor alternative is selected, a geotechnical exploration program with borings more closely spaced along the tunnel alignment will be undertaken to reduce the number of unknowns that might contribute to undesirable tunneling-related settlement. Surface settlement can be mitigated by grouting or other ground improvement techniques to stabilize subsurface soils and stop the propagation of voids before they reach the ground surface. Specifications for the design of a tunnel boring machine will address techniques and mitigation controls specific to the anticipated geologic conditions.

Excavation Safety and Stability

To mitigate the impact of excavations on ground stability and provide a safe working environment, all excavation sloping and shoring must be designed and constructed in accordance with U.S. Occupational Safety and Health Administration (OSHA) and Washington Industrial Safety and Health Administration (WISHA) standards. More stringent requirements will be set by the engineer if site-specific conditions require special treatment to maintain stability.

Spoils Disposal

Mitigation of impacts associated with erosion, sedimentation, and fouling of roadways due to disposal of construction spoils will require use of BMPs at both the source and disposal sites. To avoid erosion of stockpiled material, the materials would be stored in protected locations and covered or stabilized. Qualified engineers will designate safe slopes and heights of stockpiled material.

Operation Mitigation Common to All Systems

The following subsections describe mitigation measures for operation of Brightwater facilities.

Erosion

Operation mitigation measures for erosion include maintaining vegetation and providing adequate surface water runoff controls during the operational life of the treatment plant and conveyance facilities.

Common operational surface water controls to mitigate erosion include designing and constructing adequate storm drain systems to convey surface water either above or below ground to an appropriate discharge point. Above-ground systems include vegetated swales, ditches, and culvert systems; below-ground systems include curb-and-gutter, storm drains, and buried piping. If necessary, siltation and sediment settling ponds or similar methods could be used to meet the discharge turbidity requirements of King County, Snohomish County, and City of Edmonds and other local jurisdictions.

Contaminated Soil and Groundwater

Facilities will be designed to prevent soil contamination during operation, and plans will be developed to monitor structures and to respond if a leak is detected. The designs will include primary and secondary containment of hazardous chemicals handled onsite and collection of spills in process areas. Redundant tankage and equipment would be provided to allow isolation of individual units for inspection and repair. Process tankage will be designed with water stops at the joints to allow movement at concrete construction joints and to prevent leakage. Construction specifications will require leak testing prior to acceptance to ensure that tanks are watertight before operation begins. Piping will be designed with flexible couplings to allow for differential movement over time without leakage.

All the water-holding structures, except the influent pump station (IPS) at the Route 9 site, would be equipped with leak detection systems. In the case of the Route 9 structures and structures in the upper yard of the Unocal site, the leak detection system would double as an underdrain system. The effluent in the IPS at Route 9 would always be under a smaller hydrostatic head than the surrounding groundwater. If leakage were to occur, it would be from groundwater to the inside of the IPS. Therefore, a leak detection system would not be required to protect groundwater quality.

During operation, chemical and process treatment tankage, piping, and equipment would be emptied, cleaned, inspected, and tested on a routine basis to prevent spills and leaks. Spill prevention and response plans will be developed to prepare for and handle leaks or spills resulting from a catastrophic seismic event. Such plans could include redirecting flows to other treatment plants, storing flows in conveyance tunnels, and pumping or trucking tank contents to adjacent serviceable tanks to allow for immediate repair of the damaged units. At a minimum, plans would meet the requirements of both the Uniform Fire Code, which requires a Hazardous Material Management Plan, and the Clean Water Act regulations (40 CFR 112), which require a Spill Prevention, Control, and Countermeasures Plan for storage of petroleum products. Additional information about spill prevention is contained in Chapter 9.

Seismic Hazards

Treatment Plants

Mitigation measures for liquefaction-susceptible soil during the operational life of both treatment plant sites include the use of flexible couplings where pipes enter structures flow isolation valves, and the provision of additional pipe weight to prevent flotation. Liquefaction-induced damage to pavement, luminaires, and stormwater swales and ponds is not life-threatening and is relatively easy to repair. Therefore, no mitigation is proposed other than repairing the damage should liquefaction occur. As discussed in

Section 4.2 Affected Environment, liquefaction susceptible soil is present at both the Route 9 site and the Unocal site. The structure foundation approaches that would be used to mitigate damage from liquefaction, should it occur, are different for the Route 9 and Unocal sites and are discussed in subsequent sections specific to the individual plant site. Common mitigation approaches are discussed below.

Preliminary explorations indicate that scattered pockets of Vashon Recessional Outwash soils at the Route 9 site have the potential to liquefy during the design seismic event. The large process structures, which would be located in the eastern portion of the site, would generally be founded several feet below the existing ground surface. These structures would be either completely below the Recessional Outwash or at depths where the Recessional Outwash is too dense to liquefy. Therefore, the large process structures located on the eastern portion of the site do not have a liquefaction risk. However, there is a potential for some soils to liquefy beneath the fill that is to be placed on the lower, western portion of the site, and possibly beneath the shallow structures in the middle of the site (the Administration Building, Maintenance Building, and Chemical Building). Detailed liquefaction studies will be performed during final design, based on information from borings drilled at the specific locations of the structures, to determine the potential for liquefaction and to decide on appropriate foundation and soil preparation measures to mitigate the risk of damage. If soil amendments (e.g., soil-cement fills) are used to mitigate liquefaction risks, the mitigations will be designed such that there are no adverse impacts to groundwater or other natural resources.

Conveyance Corridors

Permanent structures at portals within liquefiable soils will be designed to withstand the earth loading associated with lateral movement of liquefied soil or will be designed to shear off without damaging the deep conveyance tunnel. Liquefaction and lateral spreading are typically shallow; access and valve shafts at relatively shallow depths can be repaired relatively quickly and cheaply without substantial impacts to the function of the conveyance system.

If surface expressions of the SWIFZ are determined to pass across the conveyance corridors, mitigation could include either designing the pipelines to tolerate the anticipated movement or putting in place an emergency repair plan. Because the risk of faulting is low and the location of faulting cannot be predicted at this time, mitigation for faulting would be limited to an emergency action plan unless contrary evidence showing increased risk is discovered.

The seismic design for the conveyance system will be conducted using the 2003 International Building Code (IBC, 2003) as the basis of design to be consistent with the planned design of the treatment plant facilities. Provisions for the 2003 IBC require earthquake design to conform to a maximum considered earthquake (MCE) with a 2% probability of occurrence in 50 years, which corresponds to ground motions having a 2,475 year recurrence interval.

All permanent structures will be designed for the MCE; however, in accordance with the IBC, the DESIGN ground motions will be specified as being equal to two-thirds of the MCE ground motions. The DESIGN ground motions (2/3rds of the MCE) will be used for:

- Structural Design
- Liquefaction Analyses
- Ground Deformation/Pseudo-Static Slope Stability Analyses

4.3.2 Impacts and Mitigation: Route 9 System

4.3.2.1 Treatment Plant: Route 9

Construction Impacts: Route 9 Treatment Plant

Mitigation measures for impacts from construction of the Route 9 treatment plant are described under Proposed Mitigation Common to All Systems. Although the magnitude of impacts differs between the Route 9 and Unocal System, there are no construction impacts unique to the Route 9 site. See the comments in Table 4-6.

Operation Impacts: Route 9 Treatment Plant

The only operation impacts unique to the Route 9 site would be seismic, related to liquefaction-susceptible soil (Table 4-6). Site grading would remove most of the potentially liquefiable soil from the eastern portion of the Route 9 site. In addition, all water-holding basins at the Route 9 site are anticipated to be located below the potentially liquefiable soils. Underdrains for the deep structures would lower the water table locally so that there would be very little risk of liquefaction around structures or nearby piping on the eastern half of the Route 9 site.

The Administration Building, Maintenance Building, and Chemical Building in the middle of the Route 9 site have the potential to be built on liquefiable soils. Liquefaction could result in differential settlement or lateral spreading beneath these building, with subsequent damage.

Shallow piping for stormwater, potable water, irrigation, and lighting; parking areas; and stormwater facilities are proposed in the western half of the Route 9 site. Liquefaction could result in rupture or leakage of pipes, pavement cracking, tilting or overturning of luminaires, and settlement or cracks in stormwater dikes. Impounded stormwater could flow overland to the ditches along SR-9. Additional studies will be conducted during final design to determine both the potential for liquefaction and the flow rate and volume of stormwater that could travel offsite if liquefaction were to occur.

Table 4-6. Potential Earth Impacts and Proposed Mitigation for the Route 9 Treatment Plant Site

Potential Impact	Description of Impact	Mitigation
Construction Impacts		
Erosion	No unique impacts; see Table 4-4.	No unique measures; see Table 4-4.
Excavated soil reuse and offsite haul of unsuitable soil	No unique impacts. For the Route 9 site and layout, an estimated 340,000 cubic yards of excess material may be taken offsite for disposal.	No unique measures; see Table 4-4.
Contaminated soil and groundwater	No unique impacts. Currently, no data exist indicating that soil beneath the Route 9 site is contaminated. However, one property is on Ecology's Suspected And Confirmed Contaminated Site List. Past and current property uses warrant site investigations during the design phase if this site is selected for the treatment plant.	No unique measures; see Table 4-4.
Landslide hazard	Previous slope movement in northeast corner of site.	Risk of future movement minimized by designing temporary excavations to preserve global stability.
Vibration and settlement	No unique impacts; see Table 4-4.	No unique measures; see Table 4-4.
Operation Impacts		
Erosion	No unique impacts; see Table 4-4.	No unique measures; see Table 4-4.
Landslide hazard	Previous slope movement in northeast corner of site.	Risk of future movement minimized by designing permanent excavations to preserve global stability.
Seismic hazard	Some of the existing fill and Vashon Recessional Outwash at Route 9 may be liquefiable. All water-holding structures would be founded below liquefiable material. Liquefaction could damage pavement, stormwater facilities, and shallow pipes in western half of site.	Over-excavation and recompaction beneath shallow foundations where liquefiable soil is present. Flexible couplings on pipes.

Proposed Mitigation: Route 9 Treatment Plant

Construction Mitigation

Table 4-6 summarizes the earth-related construction impacts and mitigation measures of siting the Brightwater Treatment Plant at the Route 9 site. Mitigation measures are as described under Mitigation Measures Common to All Systems.

Based on the results of the Phase 1 environmental site assessment (Appendix 4-D), it is expected that contaminated soil will be encountered during demolition and excavation at the Route 9 site. As noted previously, the nature and extent of contamination are not known; however, King County will conduct additional investigations during the design phase to better evaluate the likelihood of encountering soil contamination at the Route 9 site. Remediation of soil contamination at the Route 9 site is expected to be relatively routine, based on the types of contaminants likely present from current and past activities. Standard industry practices should be sufficient for managing and remediating contaminated soil, and it is unlikely that contaminant concentrations would result in classification of the soil under the Washington State Dangerous Waste regulations (Ch 173-303 WAC). Excavation and removal of the soil to a municipal solid waste landfill or thermal desorption facility (for petroleum-contaminated soil) should be sufficient to manage the soil. Two regional landfills (Roosevelt in Klickitat County, Washington, and Columbia Ridge in eastern Oregon) have sufficient capacity to accept the soil.

Operation Mitigation

The Route 9 site requires no unique mitigation measures during operation. It poses no unique operation impacts other than potentially liquefiable soil.

As described earlier in this section, there is no risk of damage from liquefaction-prone soils for the water-holding structures located in the eastern portion of the site, as these structures will be founded beneath the liquefiable soil. Structures located in the middle and western portions of the site will be founded near the ground surface. For these areas, the risk of liquefaction damage will be addressed by over-excavating the liquefaction-prone soil beneath the structure foundation and recompacting it to a greater density. Should it be necessary to amend recompacted soil to increase its strength properties, amendments would be evaluate during design to ensure no adverse impacts to groundwater. Mitigation measures are described in Table 4-6.

4.3.2.2 Conveyance: Route 9

Construction Impacts: Route 9 Conveyance

There are no construction impacts unique to the Route 9 conveyance corridors. Specific details concerning potential impacts and mitigation for the Route 9 corridors are provided in Table 4-7; excavation volumes are provided in Table 4-8.

Table 4-7. Potential Earth Impacts and Proposed Mitigation for the Route 9 Conveyance Corridors

Portal/ Tunnel Reach	Erosion Hazard	Portal Landslide/Slope Stability Hazard	Adjacent Area Landslide Hazard [a]	Liquefaction Hazard	Settlement Hazard	Existing Soil Contamination
Influent Portion of both Route 9 Corridors						
Primary Portal Siting Areas						
Portal 11	Yes Construction Mitigation: BMPs Operation Mitigation: Reestablish vegetation, provide detention if necessary	No Constr. Mitigation: None Oper. Mitigation: None	No Constr. Mitigation: None Oper. Mitigation: None	Yes (alluvium) Constr. Mitigation: Displacement grouting, repair Oper. Mitigation: Design to withstand loading from liquefied soil	Yes (alluvium may be medium to highly compressible) Constr. Mitigation: Limit dewatering & monitoring Oper. Mitigation: Design low-deformation excavation support	Possible Constr. Mitigation: Require spill prevention plans and contaminated soil contingency plans Oper. Mitigation: Require spill prevention plans
Portal 44	Same as Portal 11	No	Yes (could damage portal/ perimeter structures) Constr. Mitigation: Specify maximum groundwater drawdown, surface settlement, & vibrations. Limit construction methods and equipment in critical areas. Use underpinning, displacement grouting, or repair and releveling where other methods not viable. Oper. Mitigation: Design to withstand seismic loading	Same as Portal 11	Same as Portal 11	Unlikely Constr. Mitigation: Require spill prevention and contaminated soil waste contingency plans Oper. Mitigation: Require spill prevention plans

Table 4-7. Potential Earth Impacts and Proposed Mitigation for the Route 9 Conveyance Corridors (cont.)

Portal/ Tunnel Reach	Erosion Hazard	Portal Landslide/Slope Stability Hazard	Adjacent Area Landslide Hazard [a]	Liquefaction Hazard	Settlement Hazard	Existing Soil Contamination
Portal 41	Same as Portal 11	Possible Landslide could damage portal/perimeter structures. Construction Mitigation: Specify maximum groundwater drawdown, surface settlement and vibrations. Limit construction methods and equipment in critical areas. Employ underpinning, displacement grouting, or repair and releveling where other methods not viable. Operation Mitigation: Design to withstand seismic loading.	No	Same as Portal 11	Same as Portal 11	Same as Portal 11
Route 9–195th Street Effluent						
Primary Portal Siting Areas						
Portal 5	Same as Portal 11	Same as Portal 41	No	No Constr. Mitigation: None Oper. Mitigation: None	No Constr. Mitigation: None Oper. Mitigation: None	Same as Portal 11
Portal 19	Same as Portal 11	Same as Portal 41	No	No	No	Same as above
Secondary Portal Siting Areas						
Portals 45, 27	Same as Portal 11	Same as Portal 41	No	No	No	Same as Portal 41
Portals 7, 23	Same as Portal 11	Same as Portal 41	No	No	No	Same as above

Table 4-7. Potential Earth Impacts and Proposed Mitigation for the Route 9 Conveyance Corridors (cont.)

Portal/ Tunnel Reach	Erosion Hazard	Portal Landslide/Slope Stability Hazard	Adjacent Area Landslide Hazard [a]	Liquefaction Hazard	Settlement Hazard	Existing Soil Contamination
Tunnel Reaches						
Portal 11 to Portal 44	N/A	N/A	N/A	Same as above	Yes (loose, soft alluvial deposits near Portal 11 could possibly settle during tunneling) Constr. Mitigation: Limit ground loss during tun-neling; if necessary, ground modification Oper. Mitigation: None	Same as Portal 11
Plant Site to Portal 41	N/A	N/A	N/A	Same as above	Yes (loose alluvial deposits in North Creek valley could possibly settle during tunneling) Constr. Mitigation: Limit ground loss during tunneling; if necessary, ground modification Oper. Mitigation: None	Same as Portal 11
Portal 41 to Portal 44	N/A	N/A	N/A	Same as Portal 41	Same as above	Same as Portal 11
Portal 44 to Portal 5	N/A	N/A	N/A	No	No	Same as Portal 11
Portal 5 to Portal 19	N/A	N/A	N/A	No	No	Same as Portal 11
Route 9–228th Street Effluent						
Primary Portal Siting Areas						
Portal 39	Same as Portal 11	Same as Portal 19	No	Same as Portal 11	Same as Portal 11	Same as Portal 44
Portal 33	Same as Portal 11	Same as Portal 19	No	Same as Portal 11	Same as Portal 11	Same as Portal 44
Portal 26	Same as Portal 11	Same as Portal 19	No	No	No	Same as Portal 11
Portal 19	Same as Portal 11	Same as Portal 41	No	No	No	Same as for 195th Street Corridor

Table 4-7. Potential Earth Impacts and Proposed Mitigation for the Route 9 Conveyance Corridors (cont.)

Portal/ Tunnel Reach	Erosion Hazard	Portal Landslide/Slope Stability Hazard	Adjacent Area Landslide Hazard [a]	Liquefaction Hazard	Settlement Hazard	Existing Soil Contamination
Secondary Portal Siting Areas						
Portals 37, 24	Same as Portal 11	Same as Portal 19	No	No	No	Same as Portal 11
Portals 30, 22	Same as Portal 11	Same as Portal 19above	No	No	No	Same as Portal 44
Reaches						
Plant site to Portal 39	N/A	N/A	N/A	No	No	Same as Portal 44
Portal 39 to Portal 33	N/A	N/A	N/A	No	No	Same as Portal 44
Portal 33 to Portal 26	N/A	N/A	N/A	No	No	Same as Portal 44
Portal 26 to Portal 19	N/A	N/A	N/A	No	No	Same as Portal 44

[a] Indicates areas with mapped landslide hazard outside but adjacent to portal.

Table 4-8. Excavation Volumes – Route 9 Conveyance

	Corridor	
Portal or Tunnel Reach	**195th Street Corridor (cu. yards)**	**228th Street Corridor (cu. yards)**
Portal		
Portal 3	--	--
Portal 5	6,000	--
Portal 7	--	--
Portal 11	4,000	4,000
Portal 14	--	--
Portal 19	4,000	4,000
Portal 26	--	7,000
Portal 33	--	10,000
Portal 39	--	11,000
Portal 41	9,000	9,000
Portal 44	8,000	8,000
Portal Total	**31,000**	**53,000**
Reach		
Local Connection	6,040	6,040
Portal 11 to Portal 44	52,000	70,000
Portal 44 to Portal 41	277,000	96,000
Portal 41 to Route 9	277,000	94,000
Route 9 to Portal 39	--	75,000
Portal 44 to Portal 5	161,000	--
Portal 5 to Portal 19	107,000	--
Portal 39 to Portal 33	--	116,000
Portal 33 to Portal 26	--	135,000
Portal 26 to Portal 19	--	112,000
Portal 14 to Portal 11	--	--
Portal 11 to Portal 7	--	--
Portal 7 to Portal 3	--	--
Portal 3 to Unocal Site	--	--
Reach Total	**880,040**	**702,040**
Portal+Reach Total	**911,040**	**755,040**

Portal 41 Influent Pump Station Option

Impacts related to construction of the IPS at Portal Siting Area 41 are similar to those described for portal construction. Because of the increased level of site excavation and removal of vegetation for this option, there would be an attendant higher potential for soil erosion during construction than for portal construction alone. Construction of the IPS at the Portal Siting Area 41 would require the excavation of an approximately 10,000-square-foot, 90-foot-deep shaft to accommodate the facility. Approximately 2 additional acres would be cleared for this facility. Slurry wall construction with internal bracing is anticipated for the shaft. Inside this excavation, the pump station structure would be constructed floor by floor, and then backfilled. After the tunnel drives and pump station structure have been completed, a trench would be excavated between the portal and the station for installation of the influent and effluent pipelines. The excavation and infill volume for the shaft and auxiliary facilities is estimated to be 37,000 cubic yards.

Conversely, an influent pump station (IPS) at the Route 9 site requires an extremely deep shaft to pump flows from the conveyance to the treatment facilities, with correspondingly high excavation volumes. Relocating the IPS to Portal Siting Area 41 would eliminate deep shaft construction, resulting in significantly reduced excavation volumes. It is estimated that excavation volumes at the Route 9 site would be reduced by approximately 170,000 cubic yards under the Portal 41 IPS option. Because constructing the IPS at Portal Siting Area 41 would require more excavation than just the portal alone, the reduction in excavation volumes for the project as a whole would be approximately 130,000 cubic yards. Moving the IPS from the treatment plant site would also reduce the amount of corresponding soil erosion that could occur during excavation and infill of that volume of material.

Connections to the Existing Wastewater System

All four connections to the existing system described in Chapter 3 would be used for the Route 9 alternatives. These connections are as follows: the Kenmore Pump Station connection near Portal Siting Area 11, the Kenmore local sewer connection west of Portal Siting Area 11, the Swamp Creek Trunk connection, and the North Creek Pump Station connection.

The Kenmore local sewer connection, when necessary at a later date, would involve pipeline installation at a relatively shallow depth (average 20 feet) at the north end of Lake Washington in areas of loose alluvial soils. Short-duration microtunneling construction is likely for this connection. Earth impacts associated with this construction would be similar but of a lesser magnitude than portal construction impacts.

The Kenmore Pump Station connection would be deeper (average 40 feet); soil conditions and impacts would be similar.

The Swamp Creek Trunk would extend up the Swamp Creek valley at relatively shallow depths (average 10 feet) in areas of loose soils. Short-duration open-cut construction is likely for this connection. There would be some potential for erosion with this construction method.

The North Creek Pump Station connection would be 30 to 40 feet deep and constructed with microtunneling methods over a few months. Depending on the final location chosen for Portal 41, the connection could be completely within the alluvial deposits in the North Creek valley or may extend partially into dense, older Vashon and pre-Fraser deposits flanking the valley. Earth impacts associated with this connection would be similar to, but of lesser magnitude, than impacts associated with portal construction.

Operation Impacts: Route 9 Conveyance

There are no operation impacts specific to the Route 9 conveyance corridors. Operation impacts for the Unocal and Route 9 corridors are similar.

Proposed Mitigation: Route 9 Conveyance

Table 4-7 summarizes the earth-related construction mitigation measures for the Route 9 conveyance corridors.

Mitigation of impacts associated with the operation of the IPS at Portal 41 are similar to those identified for portal construction. As indicated in earlier discussions, the design of facilities would ensure that site surfaces are either paved or revegetated to minimize or prevent any long-term erosion after construction is complete.

4.3.2.3 Outfall: Route 9

Construction Impacts: Route 9 Outfall

Construction activity in outfall Zone 7S would result in short-term impacts to earth resources. Approximately 6,200 linear feet of outfall pipeline would be constructed using both in-water and on-land open-cut or sheeted trench methods as well as placing pipeline directly on the seafloor. The pipeline would be installed starting from the end of the conveyance line at Portal Siting Area 19, extending through the nearshore area, and ending in the main channel of Puget Sound at water depths of up to about –600 feet MLLW. Sediment disruption would occur in the vicinity of the construction zone during allowed in-water construction windows over a 10 to 12-month period.

About 1,000 feet of on-land pipeline would be necessary to connect Portal 19 to the shoreline at the top of Point Wells. Open-cut construction methods would require use of conventional land-based equipment, including an excavator, front-end loader, crane, vibratory compactor, bulldozer, and dump trucks, to excavate a trench and install pipeline up to the shoreline. Trench excavation and pipeline installation extending through the nearshore shelf area (to a water depth of approximately –80 feet MLLW) would continue using barge-mounted construction equipment. Sheeted trench construction methods to -30 feet MLLW would be used to minimize habitat impacts. The feasibility of side-casting below –30 feet MLLW would be determined through the permitting process. Beyond the nearshore area to the diffuser location, pipeline would be placed directly on the seafloor without trench excavation.

In-water construction equipment could include barges, tugboats, and barge-mounted cranes. Typical depths and widths for both on-land and in-water trench excavation for both outfall zones are presented in Table 4-9.

Table 4-9. Trench Dimensions for the Route 9 Outfall in Zone 7S

Trench Location	Approximate Depth (ft)	Approximate Bottom Width (ft)	Approximate Top Width (ft)
On-land	12-30	10-12	10-12
In-water (0 to –30 MLLW)	12-15	20	20
In-water (–30 to –80 MLLW)	0-12	5-20	5-100

MLLW = mean lower low water.

Table 4-10 presents the estimated on-land, nearshore, and offshore pipeline lengths and the estimated total volume of excavated material for open-cut construction of a Route 9 outfall in Zone 7S.

Table 4-10. Approximate Segment Lengths and Excavated Material Volume for the Route 9 Outfall in Zone 7S

Construction Method	On-Land Pipeline (ft)	Nearshore Pipeline (ft)	Offshore Pipeline (ft)	Diffuser (ft)	Excavated Volume (cubic yards)
Open-cut	1,000	700	4,000	500	30,000

Contaminated soils and/or sediments could be encountered during both on-land and in-water excavation in outfall Zone 7S. Although contaminant concentrations measured in surface sediments met all applicable regulatory and guidance criteria at every sampling location, the proximity of the outfall location to past and present industrial facilities and stormwater outfalls suggests an increased potential for undetected contamination.

In-water excavation activities could disperse contaminants bound to sediments into the water column. On-land excavation could increase the mobility of contaminants and the potential for contaminants to reach groundwater and surface water resources. In areas of known or suspected contamination, further evaluation will be performed prior to construction to identify the limits of contamination. In areas known to be contaminated, monitoring will occur during construction and excavated sediments will be handled according to a contaminated soils handling plan prepared prior to construction.

As determined by previous and ongoing geophysical and geotechnical investigations (King County, 2001; King County, 2002a; Appendix 4-C, Outfall Geophysical Surveys), the surface soils that would be encountered in the outfall Zone 7S appear to have a low risk of liquefaction and slope failure. However, the thin sediment layer covering steep offshore slopes may be susceptible to slope instability caused by seismic forces or construction vibration and disturbance. The outfall pipeline would be placed perpendicular to the seafloor contour to reduce construction impacts on steep slopes and to minimize potential pipeline damage in the event of future slope movement or failure.

Operation Impacts: Route 9 Outfall

Normal operation of the marine outfall would not significantly impact earth resources in Zone 7S. In the event of incomplete treatment or treatment plant malfunction, untreated wastewater would be mixed with treated effluent and discharged through the deep water outfall. Such a situation would only occur after multiple power failures and implementation of several flow strategies. Refer to Appendix 3-E for more information.

Regular maintenance requirements for the outfall pipeline and diffuser would include cathodic protection monitoring and periodic visual inspection of steel pipelines. Inspection and maintenance of the cathodic protection system would be performed periodically by King County staff and would not require equipment that would impact earth resources. In-water inspection of the outfall would occur every 2 to 5 years and would not significantly disturb sediments near the outfall and diffuser.

Proposed Mitigation: Route 9 Outfall

Construction Mitigation

Mitigation measures that could be used to minimize or eliminate construction impacts to earth resources in outfall Zone 7S are listed below. These mitigation measures are in addition to typical BMPs for soil stabilization, such as those listed in the City of Edmonds, Snohomish County, King County, and Ecology stormwater design guidelines.

- Sheetpiles or temporary shoring would be used for pipeline construction on-land in the intertidal zone and in the shallower subtidal zone to a depth of –30 feet MLLW to reduce the dispersion of sediments and the width of construction disturbance to the seafloor. Similar methods or open-cut construction may be used to depths greater than –30 feet MLLW.
- Seismic concerns, such as liquefaction and slope failure, would be addressed in the engineering design of the outfall and diffuser. Outfall alignments would be selected to limit potential liquefaction and slope failure during construction and operation.
- A plan for handling potential soil and sediment contamination in accordance with the Puget Sound Dredged Disposal Analysis program, administered jointly by Ecology, the Washington State Department of Natural Resources, and the U.S. Army Corps of Engineers (COE), would be prepared prior to construction. Potentially contaminated soils would be tested and, if contamination is confirmed, handled and disposed of as indicated in the plan.

In-water construction would be consistent with the requirements of numerous permitting agencies, including COE, the Washington State Department of Fish and Wildlife, and Ecology.

Operation Mitigation

Normal operation of the marine outfall would not significantly impact earth resources in outfall Zone 7S. Mitigation efforts would include periodic underwater inspections to identify and correct disturbance to marine sediments, the pipeline, or the diffuser. Regular testing would be performed to monitor any potential for long-term accumulation of contaminants in the sediments near the outfall.

4.3.3 Impacts and Mitigation: Unocal System

4.3.3.1 Treatment Plant: Unocal

Construction Impacts: Unocal Treatment Plant

Table 4-11 summarizes the earth-related construction impacts of siting the Brightwater Treatment Plant at the Unocal site. The treatment plant scenarios being considered in this EIS for the Unocal site vary in capacity (36 to 72 million gallons per day [mgd]), source of influent (with or without flows from Edmonds and Lynnwood), and "lidding" (with or without a structural feature to accommodate a multimodal transportation facility). The impacts to the earth environment are essentially the same for all of these scenarios. Although the degree of impact differs (for example, the amount of excavation), the differences are negligible for purposes of the impacts analysis and mitigation approaches.

As discussed in the Affected Environment section, the Unocal site consists of an upper yard and a lower yard. The maximum elevation difference between these two areas is about 165 feet. The treatment plant layout at the Unocal site requires permanent cut excavations of up to 100 feet to regrade the site to the desired foundation elevations for the facility. Permanent cut excavations of this magnitude and within the horizontal limits and types of soil deposits located at the Unocal site would become unstable unless mitigated.

Operation Impacts: Unocal Treatment Plant

Earth-related operation impacts of siting the Brightwater Treatment Plant at the Unocal site are summarized in Table 4-11.

Retaining wall systems built as part of the treatment plant construction or permanent slopes may become damaged or unstable during the operational life of the plant as the result of earthquake-induced forces or other factors such as inadequate surface water control. The likelihood of damage or instability is small because the walls will be designed in consideration of earthquake loads roughly equivalent to those induced during a 500-year seismic event (as determined by the 2003 IBC).

Table 4-11. Potential Earth Impacts and Proposed Mitigation for the Unocal Treatment Plant Site

Potential Impact	Description of Impact	Mitigation
Construction Impacts		
Erosion	Higher volumes of soil removed and steeper slopes would result in greater potential for erosion; see Table 4-4.	No unique measures; see Table 4-4.
Excavated soil reuse and offsite haul of unsuitable soil	For the current Unocal System and sub-alternatives, an estimated 1.6 million cy of excess soil may be taken offsite for disposal.	No unique measures; see Table 4-4.
Contaminated soil and groundwater	The Unocal site is a state-listed hazardous waste site and is currently being cleaned up by the site owner with Ecology oversight. Contaminated soil not cleaned up could be encountered during excavation and regrading.	No unique measures; see Table 4-4.
Landslide hazard	Permanent cut excavations of up to 100 feet are necessary to achieve desired operating elevations for structures. Changes in slope geometry could result in slope instability.	Permanent retaining walls will be designed and constructed to stabilize the anticipated cut excavations. Retaining wall systems could include anchored or cantilevered wall systems. Site layout is based on a maximum 50-foot vertical wall height increment. For excavation cuts greater than 50 feet, multi-tiered wall systems would be used.
Vibration and settlement	No unique impacts. No adjacent facilities to damage.	No unique measures.
Operation Impacts		
Erosion	No unique impacts; see Table 4-4.	No unique measures; see Table 4-4.
Landslide hazard	Retaining wall systems or permanent slopes may become unstable during their life because of earthquake-induced forces or other factors such as inadequate surface water control.	Retaining walls will be designed and constructed per applicable IBC and site-specific seismic design criteria. Routine monitoring and maintenance will be required for retaining wall systems.
Seismic hazard	Loose, saturated, cohesionless soil in lower yard is believed to be susceptible to liquefaction during seismic events. Liquefaction can cause differential settlement and damage to structures founded on shallow foundations and to utilities and pavement.	Structures located in the lower yard area would be founded on deep piling foundations that extend through the loose deposits and into an adequate bearing stratum. Flexible couplings on pipes entering structures.

Note: Unocal impacts and mitigation apply to both the 54-mgd capacity treatment plant and the Unocal sub-alternatives.

Long periods of high rainfall can increase the weight of soil that is already tending to move downward, thus decreasing the effective stress and therefore the resistance to movement of the supporting soil. Coupled with inadequate surface water control, which could cause erosion, this decrease in effective stress could lead to slope instability. The risk of this occurrence at engineered portions of the plant site would be small because the highest observed groundwater levels are used for slope stability analyses (typically with a safety factor added); stormwater conveyance facilities are designed for 25-year storms;

and erosion would have to remove large volumes of supporting soil to overcome the safety factor built into slope stability.

The risk of liquefaction throughout the lower yard at the Unocal site is higher than at the western half of the Route 9 site because fill and alluvium deposits in the lower yard are relatively loose, saturated, and believed to be thicker than potential liquefaction-prone soil deposits at the Route 9 site. Whereas the potential for liquefaction at the Route 9 site can be mitigated by founding structures below the liquefaction-prone soils or standard over-excavation and recompaction, structures located at the Unocal site lower yard area will likely require deep pile foundations to mitigate liquefaction. Without proper design, liquefaction could result in differential settlement of structures; differential settlement between structures and pipes; pipe and vault flotation; and damage to pavements, dikes, and luminaires.

Proposed Mitigation: Unocal Treatment Plant

Construction Mitigation

As shown in Table 4-11, construction impacts unique to the Unocal site include excavation cuts to accommodate the steep topography and removal of existing soil and groundwater contamination if the ongoing cleanup is not completed prior to the start of plant construction.

To provide safe and stable operating elevations at the Unocal site, permanent retaining walls would be designed and constructed to retain and stabilize the anticipated cut excavations. Retaining wall systems could include anchored or cantilevered soldier-pile wall systems where there is insufficient space for stable temporary cut slopes, or cast-in-place concrete gravity walls where space is available. Retaining wall systems and layouts would likely be developed based on a maximum 50-foot vertical wall height increment; for excavation cuts greater than 50 feet, multi-tiered wall systems would be used. Wall loadings would be based on the guidelines of the 2003 IBC, with additional site-specific recommendations from the geotechnical engineer. The retaining wall systems built to resist the loading would be designed to meet the Building Code Requirements for Structural Concrete issued by the American Concrete Institute (ACI, 2002).

Such wall systems have been successfully used throughout the Puget Sound region to stabilize excavation cuts. For example, at King County's West Point Wastewater Treatment Plant, a 60-foot-high retaining wall was constructed in soil conditions similar to those expected to be encountered at the Unocal site. The wall system at West Point has performed as designed, with no damage resulting from the recent earthquakes.

As noted previously, the Unocal site is currently undergoing remediation of soil and groundwater. Unocal has conducted interim remedial actions to mitigate migration of existing subsurface petroleum contaminants. For the upper yard, remediation has been completed. For the lower yard, Unocal has defined the nature and extent of contamination but has not selected the cleanup alternative; the lower yard cleanup action is expected to be determined in 2005. Because the site cleanup is regulated by Ecology, King County would likely implement the cleanup selected by and based on the work done by Unocal.

Operation Mitigation

Retaining wall systems or permanent slopes will be designed to withstand high groundwater, lateral earth loads, and seismic loading as determined by the 2003 IBC and recommendations of the geotechnical engineer. All slopes will be designed, in accordance with the local standard of practice, to have minimum factors of safety against sliding of 1.5 for static loading and 1.1 for seismic loading. Mitigation approaches commonly used for potential slope instability include designing and constructing retaining walls in accordance with applicable seismic IBC and site-specific design criteria. In addition, periodic monitoring and maintenance of retaining wall systems will be specified by the geotechnical engineer.

Structures in the lower yard would be founded on piles to prevent damage as the result of soil liquefaction during the design seismic event. Flexible couplings would be provided between piping and structures, and critical piping and vaults would be designed to resist flotation in the liquefied soil.

4.3.3.2 Conveyance: Unocal

Construction Impacts: Unocal Conveyance

There are no construction impacts unique to the Unocal conveyance alternative. Mitigation measures are described under Mitigation Common to All Systems and in Table 4-12. The Unocal corridor is shorter than the Route 9 corridors and has fewer portals; the potential for erosion would therefore be less. Excavation volumes would also be less, as summarized in Table 4-13. However, the Unocal corridor crosses more areas with loose soil subject to settlement or liquefaction.

Only the two Kenmore-area connections would be constructed for the Unocal System and the North Creek pump station connection to Portal 14. The impacts associated with these connections were previously described for the Route 9 systems.

Table 4-12. Potential Earth Impacts and Proposed Mitigation for the Unocal Corridor

Portal/ Tunnel Reach	Erosion Hazard	Portal Landslide/Slope Stability Hazard	Adjacent Area Landslide Hazard [a]	Liquefaction Hazard	Settlement Hazard	Existing Soil Contamination
Primary Portal Siting Areas						
Portal 14	Yes Construction Mitigation: BMPs Operation Mitigation: Reestablish vegetation, provide detention if necessary	No Constr. Mitigation: None Oper. Mitigation: None	No Constr. Mitigation: None Oper. Mitigation: None	Yes (alluvium) Constr. Mitigation: Displacement grouting, repair Oper. Mitigation: Design to withstand loading from liquefied soil	Yes (alluvium may be medium to highly compressible) Constr. Mitigation: Limit dewatering & monitoring Oper. Mitigation: Design low-deformation excavation support	Unlikely Constr. Mitigation: Require spill prevention and hazardous waste contingency plans Oper. Mitigation: Require spill prevention plans
Portal 11	Same as Portal 14	No	No	Same as above	Same as above	Possible Constr. Mitigation: Require spill prevention plans and hazardous waste contingency plans Oper. Mitigation: Require spill prevention plans
Portal 7	Same as Portal 14	Yes (could damage portal/perimeter structures) Constr. Mitigation: Specify maximum groundwater drawdown, surface settlement, & vibrations. Limit construction methods and equipment in critical areas. Use underpinning, displacement grouting, or repair and releveling where other methods are not viable. Oper. Mitigation: Design to withstand seismic loading	Yes (could damage portal/perimeter structures) Constr. Mitigation: Same as for Portal Landslide/Slope Stability Hazard Oper. Mitigation: Same as for Portal Landslide/Slope Stability Hazard	No Constr. Mitigation: None Oper. Mitigation: None	No Constr. Mitigation: None Oper. Mitigation: None	Same as Portal 14
Portal 3	Same as Portal 14	Same as Portal 7	No	No	No	Same as Portal 11

Table 4-12. Potential Earth Impacts and Proposed Mitigation for the Unocal Corridor (cont.)

Portal/Tunnel Reach	Erosion Hazard	Portal Landslide/Slope Stability Hazard	Adjacent Area Landslide Hazard [a]	Liquefaction Hazard	Settlement Hazard	Existing Soil Contamination
Secondary Portal Siting Areas						
Portals 13, 10	Same as Portal 14	No	Same as Portal 7	Same as Portal 14	Same as Portal 14	Same as Portal 11
Portal 12	Same as Portal 14	No	Same as Portal 7	Same as Portal 14	Same as Portal 14	Same as Portal 14
Portal 5	Same as Portal 14	No	No	No	No	Same as Portal 11
Reaches						
Portal 14 to Portal 11	N/A	N/A	N/A	Same as Portals 14	Yes (loose, soft alluvial deposits near Portal 11 could possibly settle during tunneling) Constr. Mitigation: Limit ground loss during tunneling; if necessary, ground modification Oper. Mitigation: None	Same as Portal 14
Portal 11 to Portal 7	N/A	N/A	N/A	No	Same as Portal 14	Same as Portal 14
Portal 7 to Portal 5	N/A	N/A	N/A	No	No	Same as Portal 14
Portal 5 to Portal 3	N/A	N/A	N/A	No	No	Same as Portal 14
Portal 3 to Unocal Plant Site	N/A	N/A	N/A	No	No	Same as Portal 14

[a] Indicates areas with mapped landslide hazard outside but adjacent to portal.

Table 4-13. Estimated Excavated Material Volumes for the Unocal Corridor

Portal or Reach	Volume (cy)
Primary Portal Siting Area	
Portal 3	10,000
Portal 7	11,000
Portal 11	6,000
Portal 14	2,000
Portal Total	29,000
Reach	
Local connection	5,390
Portal 14 to Portal 11	174,000
Portal 11 to Portal 7	125,000
Portal 7 to Portal 3	148,000
Portal 3 to Unocal Site	107,000
Reach Total	559,390
Portal + Reach Total	**588,390**

Operation Impacts: Unocal Conveyance

Operation impacts for the Unocal and Route 9 corridors are similar for earth-related hazards, but not the same. Table 4-12 lists operation impacts and mitigation specific to the Unocal corridor.

Proposed Mitigation: Unocal Conveyance

No specific mitigation measures are unique to the Unocal corridor.

4.3.3.3 Outfall: Unocal

Construction Impacts: Unocal Outfall

Construction impacts in Zone 6 would be generally similar to those described for Zone 7S. The pipeline would be installed starting from the Unocal plant effluent pump station, extending through the nearshore area, and ending in the main channel of Puget Sound at water depths of about –600 feet MLLW. Approximately 6,750 linear feet of outfall pipeline would be constructed using both in-water and on-land open-cut or sheeted trench methods as well as placing the pipeline directly on the seafloor. Typical depths and widths for both on-land and in-water trench excavation were presented earlier in Table 4-8.

Table 4-14 presents the estimated on-land, nearshore, and offshore pipeline lengths and the estimated total volume of excavated material for open-cut construction of Unocal outfall alignment in Zone 6.

Table 4-14. Approximate Segment Lengths and Excavated Material Volumes for the Unocal Outfall in Zone 6

Construction Method	On-Land Pipeline (ft)	Nearshore Pipeline (ft)	Offshore Pipeline (ft)	Diffuser (ft)	Excavated Volume (cubic yards)
Open-cut	1,000	950	4,300	500	31,000

As determined by geophysical and geotechnical investigations (King County, 2001; King County, 2002a), the surface soils encountered at the outfall zones appear to have a low risk of liquefaction and slope failure. However, the thin sediment layer covering steep offshore slopes may be susceptible to slope instability caused by seismic forces or construction vibration and disturbance. Some evidence exists of a previous localized submarine slide in outfall Zone 6, indicating that construction in this area may have a potential risk of slope failure. The outfall pipeline would be placed perpendicular to the seafloor contour to reduce construction impacts on steep slopes and to minimize potential pipeline damage in the event of future slope movement or failure.

Operation Impacts: Unocal Outfall

Normal operation of the marine outfall would not significantly impact earth resources in Zone 6. Normal operation of the marine outfall would not significantly impact earth resources in Zone 7S. In the event of incomplete treatment or treatment plant malfunction, untreated wastewater would be mixed with treated effluent and discharged through the deep water outfall. Such a situation would only occur after multiple power failures and implementation of several flow strategies. Refer to Appendix 3-E for more information.

Regular maintenance requirements for the outfall pipeline and diffuser include cathodic protection monitoring and periodic visual inspection of steel pipelines. Inspection and maintenance of the cathodic protection system would be performed periodically by King County staff and would not require equipment that would impact earth resources. In-water inspection of the outfall would occur every 2 to 5 years and would not significantly disturb sediments near the outfall and diffuser.

Proposed Mitigation: Unocal Outfall

Construction Mitigation

Mitigation measures that could be used to minimize or eliminate construction impacts to earth resources in outfall Zone 6 are the same as for Zone 7S (see Impacts and Mitigation, Route 9 System). These mitigation measures are in addition to typical BMPs that would be implemented for soil stabilization.

Operation Mitigation

Normal operation of the marine outfall would not significantly impact earth resources in outfall Zone 6. Mitigation efforts would include periodic underwater inspections to identify and correct disturbance to marine sediments, the pipeline, or the diffuser. Regular testing would be performed to monitor any potential for long-term accumulation of contaminants in the sediments near the outfall.

4.3.4 Impacts: No Action Alternative

Under the No Action Alternative, construction of the Brightwater treatment plant, conveyance system, and outfall would not take place and the resulting earth impacts would not occur. Under the No Action Alternative, the earth environment would essentially remain unchanged from that described in the Affected Environment section of this chapter. As noted in the Mitigation sections of this chapter, if existing contaminated soil is encountered during construction of the Brightwater System, the contaminated soil would be managed and remediated per regulatory requirements. This would result in an improved earth environment from the current situation. Under the No Action Alternative this type of contaminated soil clean-up incidental to the construction phase of the Brightwater System would not occur, or would be under a different cleanup schedule.

4.3.5 Cumulative Impacts

Temporary cumulative construction impacts could occur if other projects are built in the vicinity of the alternative treatment plant sites, conveyance corridors, and portals at or near the same time as pipeline, portal, and plant construction. This could include construction of SR-9 at the Route 9 site. This could increase the cumulative intensity or duration of impacts, such as the potential for erosion and additional truck trips for transporting soil. The risk of erosion may increase where construction occurs near water bodies or where construction phasing (to minimize conflicts between projects) requires earthwork during the wet season.

Identifying foreseeable construction projects for the next 8 years is a challenge. Generally, long-range plans are available to the public only for publicly funded projects; private development plans are available only upon submittal of a permit application. Some large construction projects that are planned, such as at the SeaTac Airport Third Runway Project, could affect the availability of disposal options for construction spoils.

No potential cumulative impacts are identified for outfall construction and operation.

4.4 Significant Unavoidable Adverse Impacts

Design and construction of the Brightwater System will incorporate measures to avoid or minimize geologic hazards and minimize construction and operation impacts on soil and sediment to the maximum extent practicable. No significant unavoidable adverse impacts to earth resources are expected to result from construction or operation of the system.

4.5 Summary of Impacts and Mitigation

Table 4-15 summarizes the potential earth-related impacts and mitigation measures for the Brightwater System alternatives.

Table 4-15. Summary of Potential Earth Impacts and Proposed Mitigation for Brightwater Systems

Brightwater System	System Component	Impacts	Mitigation
Route 9–195th Street System	Treatment Plant	Construction • Erosion – Low hazard; existing grades generally 8 percent • Import/Export of Soil Materials – Export 340,000 cy (truck volume) excess; import 120,000 cy processed sand and gravel materials • Contamination – Existing contamination sources removed; some potential for fuel, lubricant, hydraulic fluid spills • Landsliding – Hazard areas exist; improper design or construction could result in landslides extending offsite; loose soil and uncontrolled groundwater can cause increased sediment flow to surface water	Construction • Erosion – best management practices (BMPs) • Import/Export of Soil Materials – Manage construction traffic as discussed in Chapter 16 • Contamination – Require spill prevention plans and hazardous waste contingency plans • Landsliding – Proper design and construction QA plan would substantially reduce risk; consequences of failure, particularly sediment deposition in streams, would be mitigated by temporary erosion and sedimentation controls below steep slopes; larger gently sloping area at Route 9 provides added buffer for sediment control
		Operation • Liquefaction – Potential structural damage due to differential settlement or lateral spreading beneath shallow structures in middle of site; potential damage to stormwater dikes, pavement, and pipes in western portion of site • Contamination – Structure and pipe leakage could release untreated wastewater, chemicals used in treatment and maintenance • Landsliding – Same as construction	Operation • Liquefaction – Remediation by over-excavation and recompaction would eliminate liquefaction potential beneath structures; flexible couplings and design that considers flotation would protect critical pipes; easily repairable damage to stormwater dikes, pavements, and nonessential piping would be allowed to occur • Contamination – Underdrain system provides leak detection below water-holding basins; pressure testing and construction QA/QC would reduce risk of leaks; spill containment around fuel and chemical storage tanks, water recycle at washdown areas, and emergency action plans would also reduce risk of uncontrolled release • Landsliding – Same as construction

Table 4-15. Summary of Potential Earth Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Route 9–195th Street System (cont.)	Conveyance	<u>Construction</u> • Erosion – Possible at most portals, with three portals in or near mapped hazard areas • Export of Soil – Disposal of about 911,040 cy • Contamination – Unlikely except at Point Wells site • Landsliding – One primary and one secondary portal in or near mapped hazards • Liquefaction – Possible at three primary portals and tunnels in North Creek and Sammamish River Valleys • Vibration and Settlement –Same as above	<u>Construction</u> • Erosion – BMPs and Temporary Erosion and Sedimentation Control Plan • Contamination – Construction Contingency Plan and Spill Control Plan • Landsliding – Proper design and construction QA plan would substantially reduce risk • Vibration and Settlement – Specify maximum groundwater drawdown, surface settlement, and vibrations; verify by construction monitoring; limit construction methods and equipment in critical areas; employ underpinning, displacement grouting, or repair and releveling where other methods are not viable
		<u>Operation</u> • Erosion – Same as construction • Landsliding – Movement at portals could damage permanent structures • Liquefaction – Lateral spreading potential at three portals and at tunnels in North Creek and Sammamish River valleys could damage vertical shafts and piping	<u>Operation</u> • Erosion – Reestablish vegetation, provide detention if necessary • Landsliding – Design to withstand static and seismic earth loading • Liquefaction – Design to withstand loading from liquefied soil or to shear without damaging portals or tunnel
	Outfall Zone 7S	<u>Construction</u> • Erosion – Open-cut construction could erode along 1,000-foot onshore segment • Total disturbance of 6,200 linear feet • Turbidity – Open-cut excavation could increase turbidity along 700-foot nearshore segment • Contamination – Contaminated soils could be encountered in excavations for the on-land or nearshore segments	<u>Construction</u> • Erosion – BMPs identified in a Temporary Erosion and Sedimentation Control Plan, sheetpiles or temporary shoring on-land and to –30 feet MLLW • Turbidity – Perform work consistent with permit requirements, using construction methods that limit the area and duration of impact; use trench sheeting • Contamination – Perform additional evaluation in areas of potential contamination and develop a contaminated soils handling plan; implement spill prevention measures

Table 4-15. Summary of Potential Earth Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Route 9–195th Street System (cont.)	Outfall Zone 7S	• Landsliding – Excavation could trigger landsliding along steep slopes • Seafloor – Open-cut excavation and backfill would permanently alter seafloor along 700-foot nearshore segment	• Landsliding – Perform additional investigations to identify potentially unstable areas and implement construction procedures to limit disturbance • Seafloor – Design trench backfill to be level with adjacent seafloor; use native or similar material for upper part of backfill
		Operation • Landsliding – Thin layer of sediment overlying steeper seafloor slopes could naturally creep or could liquefy and flow under strong seismic shaking	Operation • Landsliding – Select minimized alignment perpendicular to slopes where the slope is steep; design outfall pipe to accommodate loss of support
Route 9 –228th Street System	Treatment Plant	• Same as for 195th Street system	• Same as for 195th Street system
	Conveyance	Construction • Erosion – Same as 195th Street system • Export of Soil – Disposal of 755,040 cy • Contamination – Same as 195th Street System • Landsliding – Four primary and four secondary portals in or near mapped hazards • Liquefaction – Possible at two primary portals • Vibration and Settlement – Potential damage to overlying and adjacent structures at two portals	Construction • Erosion – BMPs and Temporary Erosion and Sedimentation of Control Plan • Contamination – Construction Contingency Plan and Spill Control Plan • Landsliding – Proper design and construction QA plan would substantially reduce risk • Liquefaction - Design to withstand loading from liquefied soil or to shear without damaging portal • Vibration and Settlement – Same as for 195th Street System
		Operation • Erosion – Same as 195th Street System • Landsliding – Movement at portals could damage permanent structures • Liquefaction – Lateral spreading potential at two portals could damage vertical shafts and piping	Operation • Erosion – Reestablish vegetation, provide detention if necessary • Landsliding – Design to withstand static and seismic earth loading • Liquefaction – Design to withstand loading from liquefied soil or to shear without damaging tunnel
	Outfall Zone 7S	• Same as for 195th Street System	• Same as for 195th Street System

Table 4-15. Summary of Potential Earth Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Unocal System	Treatment Plant	Construction • Erosion – Moderate to high hazard; up to 100 feet of total temporary excavation depth over site • Import/Export of Soil Materials – Export 1.6 million cy (truck volume) excess excavation, import 500,000 cy processed sand and gravel materials • Contamination – Same as Route 9 • Landsliding – Same as Route 9, but higher hazard due to larger cuts and steeper slope into poor materials	Construction • Erosion – BMPs • Contamination – Require spill prevention plans and hazardous waste contingency plans • Landsliding – Same as Route 9, but smaller level mitigation area is available at the base of slopes
		Operation • Liquefaction – Potential structural damage due to differential settlement or lateral spreading beneath structures in the lower yard • Contamination – Structure and pipe leakage could release untreated wastewater, chemicals used in treatment and maintenance • Landsliding – Same as construction	Operation • Liquefaction – Remediation by pile support of structures on lower yard; flexible couplings and design that considers flotation would protect critical pipes; easily-repairable damage to stormwater dikes, pavements, and nonessential piping would be allowed to occur • Contamination – Underdrain system on structures in upper yard would provide leak detection below water-holding basins; other mitigation same as Route 9 site • Landsliding – Same as construction

Table 4-15. Summary of Potential Earth Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Unocal System (cont.)	Conveyance	Construction • Erosion – Possible at most portals, with one portal in or near mapped hazard areas • Export of Soil – Disposal of about 588,390 cy • Contamination – Possible in commercial areas and near Unocal site • Landsliding – Two primary and three secondary portals in or near mapped hazards • Liquefaction – Possible at three primary portals and three secondary portals and at tunnel segments in North Creek valley and near Lake Washington • Vibration and Settlement –Potential damage to overlying and adjacent structures in same areas as liquefaction potential	Construction • Same as for Route 9–195th Street System
		Operation • Erosion – Same as construction • Landsliding – Movement at portals could damage permanent structures • Liquefaction – Lateral spreading potential at portals and in tunnel segments could damage vertical shafts and piping	Operation • Same as for Route 9–195th Street System
	Outfall Zone 6	• Similar for outfall Zone 7S. Construction would disturb 6,750 linear feet. • Opencut excavation could increase turbidity along 950-foot nearshore segment. Open-cut excavation would permanently alter seafloor along 950-foot nearshore segment.	• Same as for outfall Zone 7S
No Action Alternative		• No impacts identified	• None

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